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Sky and TELESCOPE

LORAN: worldwide grid for navigators

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Cosmogonical Implications of the Atomic Bomb—II

Stars for December

BETTER THAN YESTERDAY

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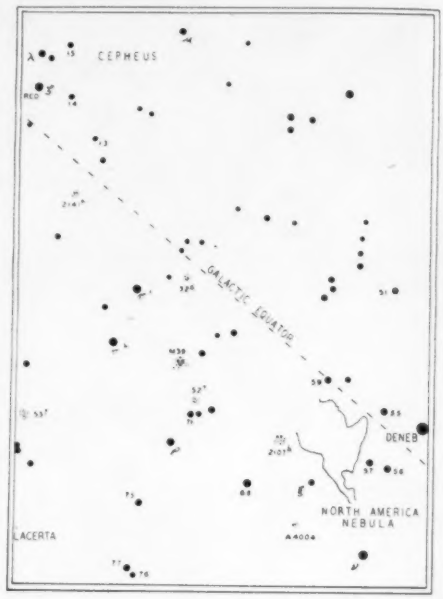
In Focus



FOR THE THIRD TIME in six months, our back cover contains the famous North America nebula, this time in the lower right corner, where this picture overlaps the one published in the August issue. Its relationship with neighboring dark and bright regions of the Milky Way is well shown here and in the August picture. The nebula was reproduced on a large scale in July.

The galactic equator is marked on the accompanying chart; its course on the photograph is difficult to trace among the multitude of stars in the region, relatively few of which are included in the chart. And a star's color influences its prominence in the photograph to such an extent that it may be unrecognizable. Such a case is Zeta Cephei, visually of magnitude 3.6, but of spectral class K0; it is in the upper left corner of the field.

In this region are a number of clusters, some very easy to find, others imbedded in star clouds of the Milky Way. Seven clusters are identified on the chart; 537 is in Lacerta, whose boundary runs near the left edge of the reproduction.

Many of the charts in the Ross-Calvert atlas are included in the catalogue of astronomical photographs available from Yerkes Observatory, Williams Bay, Wis. From Yerkes, and also from Mount Wilson Observatory, anyone may order, at reasonable cost, prints and lantern slides of a wide range of astronomical subjects.

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WHOLE NUMBER 50

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BACK COVER: The Milky Way in Cygnus and part of Cepheus, a portion of Plate 18 of the Ross-Calvert **Atlas of the Northern Milky Way.** Photo courtesy University of Chicago Press. The photograph was taken by Frank E. Ross, at Flagstaff, Ariz., October 14, 1930, exposure 3 hours, using a 5-inch, f/7 Ross-Fecker camera, now the property of Mount Wilson Observatory.

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LORAN

By FLETCHER G. WATSON
Lt. Comdr. USNR
and
HENRIETTA H. SWOPE
of the *U. S. Naval Hydrographic Office*

A loran transmitting station on an isolated islet in the Central Pacific. Fifteen to 20 Coast Guardsmen are required to keep each station operating. The transmitting antenna is in the center of the circular "ground system." Other poles support antennas for emergency use and for receiving distant signals. U. S. Coast Guard photograph.

LORAN—the new LOng Range Aid to Navigation—is already accepted by military navigators as comparable in accuracy and reliability with the long-established methods of celestial navigation. The permanent value of loran cannot be in doubt when ships report, "By means of this equipment a transatlantic convoy actually made a perfect landfall following a three-day storm in which no reliable celestial sights were obtained. Up until then the accuracy of loran fixes could only be judged by their proximity to celestial fixes. Making a landfall was the acid test."

While prewar radio ranges and radio direction finding were not reliable at ranges exceeding 150 to 200 nautical miles, loran provides patterns of *fixed* lines of position to ranges of 1,400 miles from the shore-based transmitters. Special loran charts show these patterns ready for immediate use. Even at the extreme range, the accuracy of loran lines is comparable with that of lines obtained from celestial observations. And when celestial observations can not be obtained, loran is a great aid to navigators; as witness of this is a comment from a ship in the foggy Aleutian area.

"Bad weather has made it impossible, except on rare occasions, to obtain sun sights, so that an accurate comparison cannot be made. From experience, however, loran is considered by this unit to be the outstanding single piece of equipment yet installed."

Only severe static, which blocks all other radio devices, can hamper or prevent the use of loran, but such severe conditions are fortunately rare.

Other advantages of loran can be briefly summarized. A three-line fix can be obtained in less than 10 minutes. Loran is equally useful on ships and aircraft. The equipment is relatively small—an aircraft installation weighs only about 35 pounds. These advantages have made military navigators enthusiastic about loran; many already consider it the primary aid to navigation. In peacetime its use by commercial air and surface carriers should prove equally valuable.

Loran was developed at the Radiation Laboratory of the Massachusetts Institute of Technology, and was undergoing its first tests on December 7, 1941. By the autumn of 1942, after some modifications had been made and tested, naval vessels were carrying out trial operations in the stormy North Atlantic, where convoying and anti-submarine operation required the best possible navigation. The results were sufficiently promising for the Navy to take over; the Coast Guard was assigned the responsibility of constructing and operating the shore stations. Installations were then rushed in the Aleutians, at that time a critical war front. During 1944 and 1945, loran coverage was extended rapidly over the combat areas and long supply lines of the central and western Pacific.

At the end of hostilities, some 60 million square miles, three tenths of the entire earth's surface, were covered by loran patterns. (See the front cover.) Additional installations are contemplated to cover areas of continuing military interest and the major commercial traffic lanes used by air and surface craft.

Loran utilizes accurate measurements of the time difference between the arrival of two short radio signals transmitted by a pair of widely separated shore stations. The application of electronics developed from television research has created receiving gear which acts as an electrical stop watch capable of measuring, directly and accurately, these time differences to one millionth of a second—one microsecond.

The pair of transmitting stations used to create each pattern of lines of position is located on the shore and the stations are generally separated by baselines of 250 to 350 nautical miles. In each pair, of which 47 are now operating, one station, called the *master*, transmits a short signal a number of times each second. At the second station, called the *slave*, similar pulses are transmitted in rigorous synchronism with those from the master station. If both signals were sent out simultaneously, they would arrive simultaneously along the perpendicular bisector of the baseline. On either side of this center line, the signal from the nearer station would arrive first and the time difference observed would depend upon the location of the receiver. The locus of points of a constant time difference, or reading, forms a hyperbolic line which has the transmitting stations at the foci. Thus, for each possible reading there exists a hyperbolic line of position, as Figure 1 shows.

In actual operation the signals are not transmitted simultaneously. The slave signal is not transmitted until the corresponding master signal has been received at the slave station and an arbitrary, but accurately controlled, delay added. Thus the master signal is always received first, irrespective of

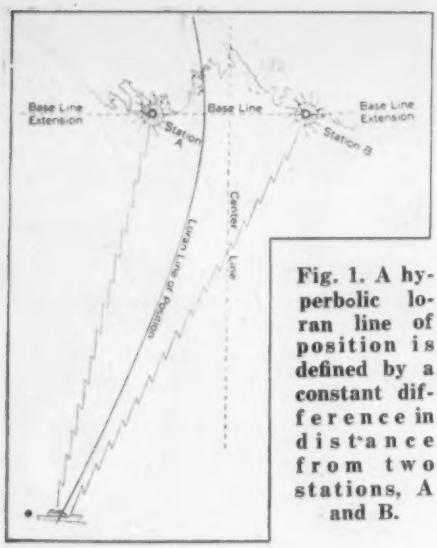


Fig. 1. A hyperbolic loran line of position is defined by a constant difference in distance from two stations, A and B.

the location of the receiver. Furthermore, the numerical value of the readings increases constantly from some minimum at the slave station to a maximum at the master station, and there are no zero or ambiguous near-zero readings.

From Figure 2 it is apparent that the greatest concentration of loran lines, and therefore the greatest linear precision of position, occurs along the baseline between the transmitters. With present equipment and operating technique, a displacement as small as 500 feet along the baseline can be observed. If the *Queen Mary* were turned parallel to the baseline, observers at the bow and stern would obtain readings differing by two microseconds.

Such precision adjacent to shore has often been used to locate channel buoys in a fog by the simple procedure of "homing" along the proper loran line. For example, the USS *Mac Leish* (DD220) reported, "Operating in the Casco Bay, Maine, area under conditions of very poor visibility and after extended maneuvers, it furnished information exact to within 100 yards in returning to the swept channel." As the loran lines go out from the transmitting stations they diverge, but even at 1,000 miles the distinguishable lines of position are generally separated by less than a mile.

From Figure 2 it is also apparent that the lowest precision in loran coverage occurs around the extensions of the baseline beyond the transmitters. On these extensions the readings reach a minimum (slave extension) or a maximum (master extension), and in the adjacent areas the readings change slowly with position; these areas must be considered regions of low reliability.

The synchronism of loran signals is maintained with a tolerance of plus or minus two microseconds. If for any reason this tolerance cannot be held, the transmitted signals are blinked to warn navigators that synchronism is momentarily lost. Separate monitor stations also keep continuous watch on the precision of transmissions.

The radio frequencies used for loran are near the standard broadcast band, and the peculiarities of loran propagation are similar to those encountered with broadcasts. For propagation over sea water during the daytime the signals are useful to ranges of 600 to 800 nautical miles. At night, the greater radio noise overrides the weak signal at these ranges and decreases the useful nighttime range of the direct signal, or ground wave, to about 500 to 600 miles. However, when the sun is near or below the horizon, a number of signals reflected from the ionosphere are received, just as distant stations can be received on your home radio at night. Of these so-called sky waves, those bounced once off the ionosphere are sufficiently stable to be used for navigation. With these sky waves, the nighttime coverage of loran is extended to about 1,400 nautical miles, where the lines of position obtained are accurate to about three miles.

Over land the direct signals are rapidly weakened. At the earth's surface, 150 nautical miles is the practical limit of useful ground wave signals. However, in the air at elevations exceeding 3,000 to 5,000 feet, the range is considerably greater. Because the coastal stations are normally separated by 250 to 350 miles, relatively little useful overland coverage during daylight can be expected. In the Burma area, there were special installations to give loran navigation over the Hump; here the transmitters were less than 70 miles apart and aerial navigators were able to use the ground waves out to 300 miles. At night, the sky waves are received as well over land as over water, and proved extremely valuable to R.A.F. night operations deep over Europe where no other type of navigational aid was available.

Actual navigation with loran, the translation of the time-difference readings into lines of position over the earth's surface, is performed with either special tables or charts prepared principally by the U. S. Hydrographic Office. In practice, the tables providing latitudes and longitudes of points on loran lines of position are entered with the reading taken from the receiver and a rough dead-reckoning position; two adjacent points on the desired line are plotted; and the line drawn on the plotting sheet which carries the ship's track. An experienced operator can enter the table, perform the necessary interpolation, and plot a line segment in approximately one minute. The several observations and plots necessary for a fix require from three to 10 minutes.

Air navigation can be done on special loran charts showing the hyperbolic lines of position. These charts, designed primarily for aircraft, have a scale of 30 or 60 miles to the inch, and, for some areas, 15 miles to the inch. The various patterns of lines are shown on the charts in distinctive colors to aid pattern identification. Furthermore, in certain areas where numerous mutually confusing patterns could be

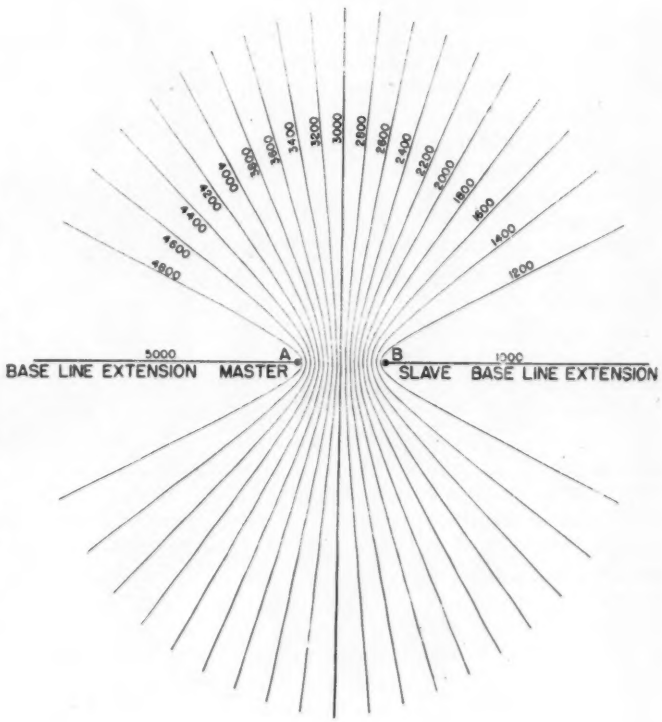


Fig. 2. A typical pattern of loran lines of position. Readings increase from 1000 on the slave baseline extension to a maximum, in this case 5000, on the master baseline extension. Each loran line is a portion of a hyperbola, a curve such that the difference in its distances from two points has a constant value.

shown, a selection has been made of those, usually four, considered most useful.

At present, loran signals are transmitted on four adjacent radio channels. Because pulses are used, the signals transmitted by each station must cover a band of some 50 to 70 kilocycles. But numerous station pairs can use the same radio channel by transmitting slightly different numbers of signals per second. Thus the radio channel and the pulse recurrence rate are the distinguishing characteristics of the various station pairs. By three switch settings, similar to push-button tuning, the receiving equipment can be put on any of the radio channels and can be synchronized with any of the recurrence rates. For example, eight loran patterns, generated by 11 stations operating on the same radio channel, provide complete coverage of the North Atlantic shipping track. Figure 3 illustrates a typical loran fix from two lines of position.

To obtain a precision of one microsecond in the time-difference measurements, the incoming signals are presented on the face of a cathode-ray tube where they can be viewed and brought to superposition. Several steps of electrical magnification are applied during the manipulation so that the actual pulse shapes are clearly seen. Figure 4 shows photographs of the final phases of the matching procedure; the line outlining the pulses has a thickness of about one microsecond.

If the static or radio noise is high, the pulse outline will be blurred, but the eye is able to integrate the images and satisfactory readings can be had. Thunderstorms produce many static "crashes" which prohibit the use of wireless telegraphy because the continuity of incoming signals is broken. But on a loran 'scope, such crashes flash on and off like a single bad frame in a movie film; they are disregarded and the signals are matched during the quiet moments. Thus, loran operation is hampered or prevented by only the most severe static conditions, such as the effects of magnetic storms or heavy precipitation static.

Development and improvement of loran receivers, both for ships and aircraft, continue. Several modifications of both types of gear have been used by the services. In one new shipboard type, the reading is taken directly from a dial similar to a speedometer. In the earlier sets, the reading was taken from successive calibrated scales. In airborne gear, emphasis has been principally upon compactness and light weight. Two models are currently in use; one weighs some 55 pounds and the other 35 pounds; new airborne sets will probably weigh less. No postwar market price of a loran receiver has been set, but estimates run from $500 to $1,500.

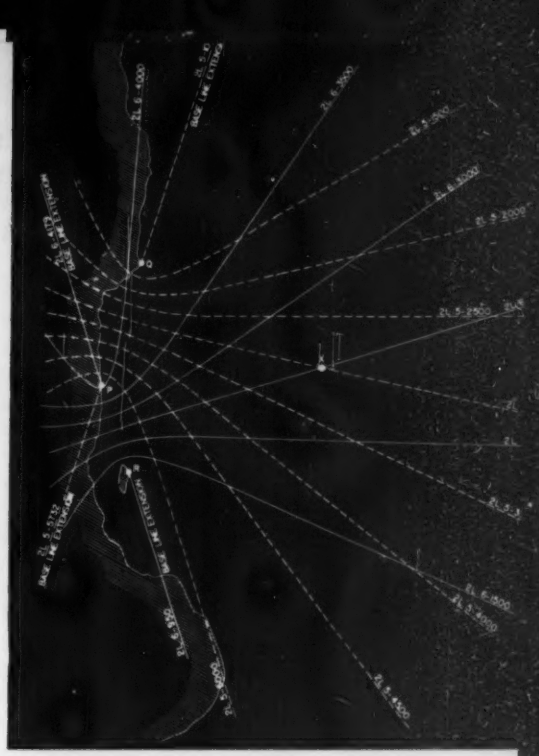
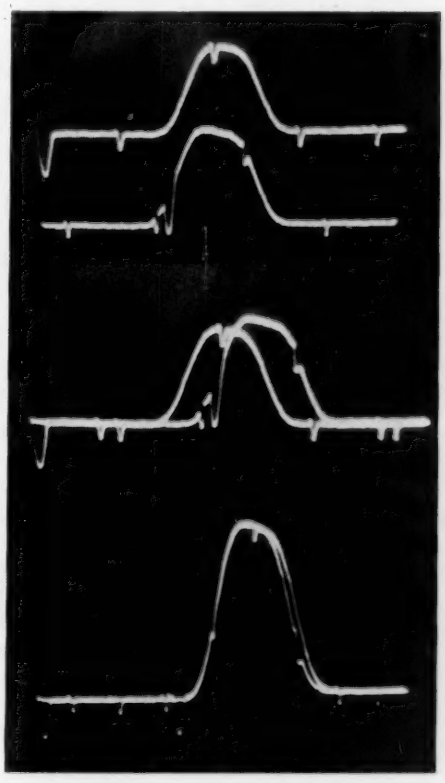


Fig. 3. A portion of a model loran chart shows how the lines of position from one pair of stations cross those from another pair, enabling the navigator to establish a fix. In this case, loran readings of 2L-5-3000 and 2L-6-2500 provide a fix at the point X. The master station is P, with slave stations at Q and R.

The United States Coast Guard is operating the majority of the 70 loran stations now on the air. The network of 10 stations in China, designed to assist navigation over the Hump, and three in western Australia, have been built and operated by the U. S. Army Airways Communication Service. The Royal Air Force operates 10 stations providing coverage over the northeastern Atlantic, parts of Europe, and the Bay of Bengal. Coverage off Nova Scotia and the fogbound Grand Banks is supplied primarily by stations operated by the Royal Canadian Navy.

As service expands over the critical trade routes, it is expected that other governments will become operating agencies. It is most desirable that uniform minimum standards for operating techniques and precision be accepted. Furthermore, it is essential that candid information on the operational status and plans of the various countries be readily available to all operating agencies and navigators. Under such conditions, loran will provide worldwide precision navigation for ships and aircraft.



The present loran system was developed as a wartime aid to navigation and rushed into operation without waiting for improvements in the equipment. The construction of 70 transmitting stations, some in exceedingly isolated places, and the procurement and installation of many thousands of sets of receiving equipment in less than three years, have required concentrated effort by hundreds of people. This effort, with its headaches, appears well worth while when reports are received like this one from the XXI Bomber Command operating from the Marianas.

"Our navigators have been using your signals to great advantage. On several occasions we have managed to bring a plane back with loran when all other means have failed. There is no doubt that you have saved us several planes and many men. Your service will be appreciated more when the rain squall season covers this area and it [loran] is the only means of navigation."

Fig. 4. Final adjustment of the cathode-ray tube screen patterns.

Top: Two loran ground-wave signals are isolated and magnified ready for fine-positioning. The regularly spaced down-marks are 50-microsecond markers; the longer markers indicate 500-microsecond intervals.

Middle: The two traces have been superposed and the pulses are about to be carefully aligned.

Bottom: The gain has been increased and the left sides of the pulses carefully matched. By readings on three calibrated scales, the time delay required to superpose these signals can be determined.

NEWS NOTES

By Dorrit Hoffleit

LICK OBSERVATORY CHANGES DIRECTORS

Dr. J. H. Moore, who has been director of Lick Observatory since 1942, is retiring on December 1st and his successor is Dr. C. D. Shane. Dr. Moore will, however, remain on the observatory staff as astronomer for a time in order to complete work that was laid aside during the war. He has been associated with Lick Observatory since 1903. From 1909 to 1913, he was with the Mills expedition to Chile, where excellent spectra of the bright southern stars were secured. He is interested in solar eclipses, and went on eclipse expeditions in 1918, '22, '23, '30 and '32. The retiring director has done significant work on spectra, spectroscopic orbits, radial velocities, the rotations of planetary nebulae, and on solar motion.

Professor Shane has been with the University of California since 1920, when he obtained his doctorate there. He has been chairman of the department of astronomy at Berkeley since 1941. His astronomical contributions are in the fields of spectroscopy and spectrophotometry.

LARGEST LUNAR MAP

H. P. Wilkins, well-known English selenographer, reports that he has just completed a map of the moon 25 feet in diameter, based on photographs and on visual observations with a 12½-inch reflector of his own construction. The map is claimed to be the largest and most detailed in existence. While the original is to be retained by the library of the British Astronomical Association, it is contemplated that the map be reproduced on a reduced scale 100 inches across, in 25 sections 20 inches square.

This map is successor to two earlier lunar charts by its author, one of 60 inches diameter made in 1924 and another of 200 inches, in 1932. The latter, in particular, has been widely reproduced on a reduced scale. The new chart should prove of value to observers interested in detecting variations in lunar surface detail.

TIME AND RADIO

Although experimental radio broadcasts in this country date back to 1906, November of 1920 marked the beginning of regularly scheduled programs, when the results of the Harding-Cox election were reported. The National Association of Broadcasters celebrated radio's 25th anniversary in November, not long after Sir Harold Spencer Jones, astronomer royal in England, gave a BBC broadcast on "The Six Pips—Twenty-One Years of Greenwich Time Signals." This talk is reprinted in *Popular Astronomy* for October, 1945.

In 1924, the first of a new type of pendulum clock was installed at Greenwich, determining time to 1/20 of a second. At the suggestion of Mr. Hope-Jones, Greenwich Observatory and BBC arranged to broadcast this time for the general public. The last of six pips heard over BBC tells to within 1/20 second each quarter hour.

Shortly, even higher accuracy will become available to those who need it, for quartz crystal clocks, similar to those already in use for short-wave time signals originating at the U. S. Naval Observatory, are being installed at Greenwich to replace the present pendulum standard clocks.

ELECTROMAGNETIC METEORITE CANE

In *Popular Astronomy*, Dr. Lincoln La Paz, president of the Society for Research on Meteorites, describes an electromagnetic cane which facilitates discovery of meteorites near the surface of the ground and eliminates many a stoop-over backache.

A small coil of enameled wire wound on a brass tube about two inches long can be made to slide up and down a light but strong iron rod. Using the electromagnet connected to a 6-volt Burgess Uniflex battery, carried in a knapsack, Dr. La Paz found that his cane could readily pick up an Odessa iron meteorite weighing more than a pound, and caused "smaller fragments to jump an inch or more to the collecting tip."

Dr. La Paz, who has been professor of mathematics at Ohio State University, has recently been appointed head of the department of mathematics at the University of New Mexico, and director of its new Institute of Meteoritics.

CANADIAN PHYSICIST JOINS YERKES STAFF

Dr. G. Herzberg, well-known physicist and spectroscopist, and formerly professor of physics at the University of Saskatchewan, is now on the staff of the Yerkes and McDonald Observatories; he is also associate professor of spectroscopy in the department of astronomy and astrophysics of the University of Chicago. Dr. Herzberg was one of the chief scientists on the recent eclipse expedition to Bredenbury, Sask., under the leadership of Comdr. Donald H. Menzel.

MOUNT WILSON'S DIRECTORS AND MOUNT PALOMAR

On January 1st, Dr. Walter S. Adams, director of Mount Wilson Observatory, will retire, his place to be taken by Dr. Ira S. Bowen, astronomer and physicist at the California Institute of Technology. In addition, it has been announced that Mount Palomar and Mount Wilson will be placed under a single administrative management.

The administrative merger will become effective as soon as the 200-inch telescope is completed. The research program will be co-ordinated with courses of study and research on the campus of California Institute of Technology, which will share with the Carnegie Institution of Washington the financing of the program of the world's two largest observatories.

In 1904, when G. E. Hale founded the Mount Wilson Solar Observatory, he brought with him E. E. Barnard, G. W. Ritchey, and Dr. Adams, who became director in 1923. The retiring director is best known for his work in stellar spectroscopy: radial velocities, spectroscopic luminosities, and parallaxes. To him goes the main credit for developing the modern technique of determining the absolute magnitudes of stars from the intensities of critical lines in their spectra. By this method, he and his associates have measured magnitudes and distances of more than 4,000 stars.

Perhaps Dr. Adams' most spectacular achievement was his success in obtaining the first spectrum of the faint companion of Sirius, proving the nature of that unbelievable class of star —the white dwarf.

Dr. Bowen is a physicist, associated with California Institute of Technology since 1921. In 1927, he succeeded in showing that "nebulium," mysterious element from which previously unidentified lines in the spectra of gaseous nebulae were supposed to originate, was in reality the common elements oxygen and nitrogen. The electron jumps producing the puzzling lines correspond to certain "forbidden" transitions. It was then not possible to produce these atomic changes on the earth because the necessary physical conditions could not be attained. In the nebulae, high degree of vacuum to a great depth, and radiation from very hot stars, together make possible the production of the "forbidden" lines observed in the spectra of the nebulae.

The new Mount Wilson director is also known as the inventor of the image-slicer, a device whereby the light of the entire image of a star is collected for passage through the relatively narrow slit of a spectroscope.

The Christmas Star

By Robert R. Coles, *Hayden Planetarium*

As the Star of Bethlehem adds its spiritual luster to the Christmas season, Hayden and Buhl Planetarium visitors view the skies of nearly 2,000 years ago, and hear a discussion of the possible astronomical explanations of the star's origin.

THE STARS belong to Christmas. They are as definitely a part of it as Christmas trees, holly wreaths, and Christmas carols. To many it almost seems that some magic pervades the heavens at the Christmas season, adding new beauty that is missing at other times. As we search the night sky, watching stars at once familiar and yet inaccessibly remote, our thoughts wander back to that first Christmas of long ago. The reasons underlying this association of the stars with Christmas have their origin in man's rich heritage of religion, mythology, history, and science. There is also a relation to our sun, daytime star.

Many centuries ago, Christian people celebrated both the Nativity and the Epiphany together on the 6th of January. There was a pagan festival to the sun at the time of the winter solstice, about December 25th. The sun's importance to man had been recognized from the earliest times; its relation to the seasons and the growth of essential crops was common knowledge. As winter approached, the sun dropped lower at noon and the cold increased. The pagan mind became very much concerned; sacrificial fires were lighted and prayers and supplications were offered that the sun might return once more with life-giving radiance and warmth.

Then came the winter solstice, when the sun reached its farthest south. Though the cold would continue and would even increase, the sun itself would begin its return northward. At last the sun-god had answered the prayers of the people. Here was an event of major importance to the whole living world. And in keeping with its great importance was the pagan festival of December 25th, the celebration of the rebirth of the sun.

Many of those who professed the Christian faith were greatly attracted by the gaity of the pagan celebration, and it became evident to the leaders of the church that they were losing their followers to the pagan belief. It was eventually decided to move the date for the celebration of Christmas to December 25th, and many of the customs of the primitive festival became mingled with those of Christmas. The 6th of January was retained as the time for celebrating the Epiphany.

This aspect of Christmas is greatly overshadowed in the minds of most people by the mystery of the famous Star of Bethlehem. What was the star that appeared to the Magi of the east? This question stands uppermost in the minds of many people each year as the Christmas season approaches. A definite answer is impossible. Some believe that the star the Wise Men saw was a vision that appeared to them alone, and any attempt at scientific explanation tends to rob the event of its sacred nature. But it is true that many phenomena which were once interpreted as miracles have since been explained, in part at least, in scientific terms. In the light of modern astronomical knowledge, we may attempt to determine if there was anything that may have appeared in the heavens at the time of the first Christmas which might have been interpreted as the famous star.

As told in the Gospel of St. Matthew, Chapter II, the story of the Christmas star reads:

"Now when Jesus was born in Bethlehem of Judaea, in the days of Herod the king, behold, there came wise men from the east to Jerusalem,

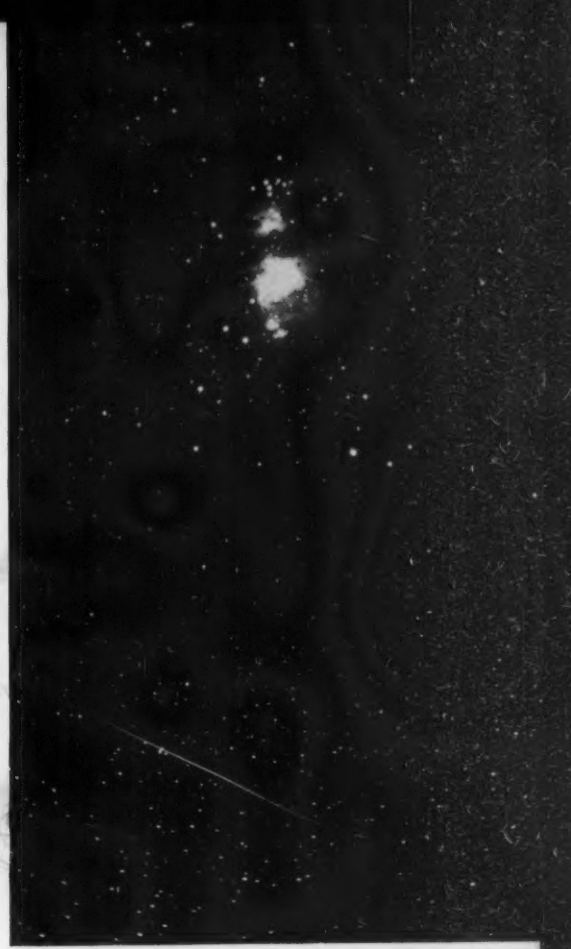
"2 Saying: Where is he that is born King of the Jews? For we have seen his star in the east; and we are come to worship him." And the star is again referred to in verses 9 and 10:

"9 When they had heard the king, they departed; and lo, the star, which they saw in the east, went before them, till it came and stood over where the young child was.

"10 When they saw the star, they rejoiced with exceeding great joy."

At first it might seem a very simple matter merely to reconstruct the sky picture as it was at the time of the Nativity and so determine what conspicuous object might have been seen. And, indeed, this would not be too difficult but for the absence of one essential fact. There is no general agreement today as to the precise year that the Nativity occurred. It is not mentioned in the Scriptures and there has been disagreement among historians.

The Roman abbot, Dionysius Exiguus, who introduced the use of B.C. and A.D. in reckoning dates, placed the Nativity in the year 754 A.U.C. or 754 years after the founding of the city of Rome. For many years this chronology of Dionysius was pretty generally accepted, although we now know that it is incorrect.

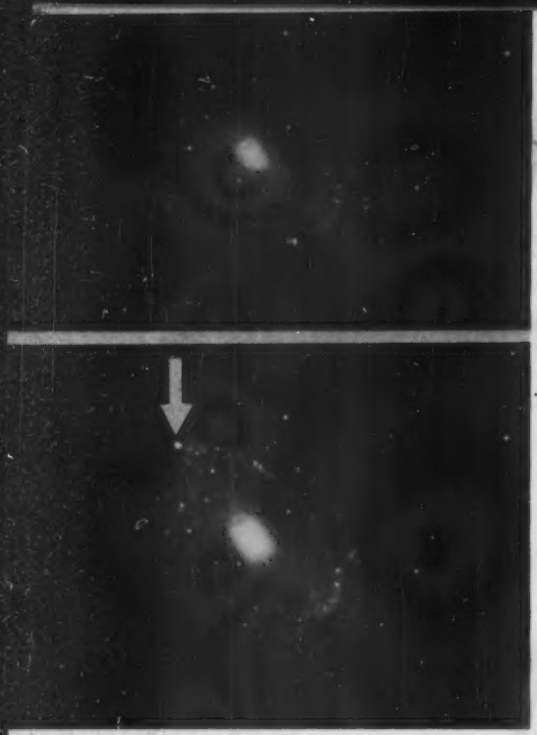


A meteor flashed across the region of the Orion nebula while this picture was being taken.

From the *New Testament* account, we note that the Nativity occurred in the reign of Herod the Great. And it was established by the historian Josephus that Herod died in the year 750 A.U.C., or what would be 4 B.C. according to the chronology of Dionysius. Josephus also mentions that there was a lunar eclipse just a short time before Herod died. And the astronomer, figuring back, finds that there was an eclipse of the moon which could have been observed at Jericho on March 13th in the year 4 B.C.

It is safe to assume that the Magi were more than casually acquainted with the stars. This being so, the regular motions of planets and stars would not have seemed extraordinary to them, while they would undoubtedly have taken note of anything unusual that appeared in the heavens early in 4 B.C.—or in some year prior to that date. Let us list the celestial phenomena which the Magi would consider striking:

Supernova. Most ordinary novae, or new stars, do not reach the great brilliance generally attributed to the Star of Bethlehem. But if a supernova flashes forth almost anywhere in the Milky Way system of stars, it is bound



In 1940, this supernova, 40 million times as bright as the sun, appeared in the spiral nebula NGC 4725. The upper picture was taken in 1931. The galaxy is in the Ursa Major group, 5½ million light-years distant. Mount Wilson photo.

to create a great stir among astronomers, even today. A few supernovae have left their mark in the history of the science. One was discovered in the constellation of Cassiopeia by Tycho Brahe in 1572; when at maximum brightness it was visible by day and was said to have rivaled Venus in splendor. In 1054, the Chinese recorded what is believed to have been a supernova, and in 1604, there was observed a star of much greater brilliance than an ordinary new star.

Although surely to be classed as miracles by the ancients, novae are not really new stars, as their name implies. They are actually faint stars which suddenly flare up to extreme brilliance; how bright we see them depends on their distances from us. Occasionally a nova surpasses every other star in its region of the sky. After a time, a nova or supernova is bound to fade, sometimes seeming to disappear as rapidly as it rose to prominence. This disappearance was especially marked before the invention of the telescope made it possible to follow such stars below naked-eye visibility. Just why a new star suddenly releases a great store of its energy is one of the mysteries astronomers are close to solving today. Supernovae, however, may actually result from the collision of two stars.

As there are apparently no records of a supernova or nova at about the time of the Nativity, it is extremely difficult to prove that this was what the Wise Men saw.

Meteor. Another possibility, though improbable, is that they may have been attracted by an unusually brilliant meteor or "shooting star." Some meteors are bright enough to be seen by day, but their transitory character makes them fit poorly into the Biblical account.

Venus. An interesting theory is that it may have been simply the planet Venus shining brilliantly as a morning or evening star. While lacking much of the dramatic appeal that belongs to novae and meteors, it is true, nevertheless, that this strikingly beautiful neighbor of ours has always stimulated the curiosity of mankind. During the past summer and fall, when Venus shone so prominently in the eastern sky every morning, the Hayden Planetarium often received several inquiries a day asking what it was. While the Magi had certainly observed this planet on many occasions before, it is not at all impossible that when they were watching for a sign Venus' appearance may have taken on a new meaning for them.

Comet. Comets are renegades of the solar system that have many times been interpreted as omens and portents, associated with both good and evil. Often they appear in majestic splendor, slowly moving through the heavens against the backdrop of stars. A comet is sometimes visible for several weeks or months, and a conspicuous tail might well appear to be leading to some far-off place beyond the horizon. And to make the theory more convincing, there is a record of a great comet seen from February until April in the year 4 B.C. Could this have been the sign the Magi followed?

Planetary conjunction. An unusual configuration of the planets attracts attention even in our supposedly sophisticated age. Perhaps the most interesting theory relates the Christmas star to such an occurrence. Associated with this theory is the name of Kepler.

On the 17th of December, 1603, Kepler observed Jupiter and Saturn in close conjunction, and in the fall of the following year, when they were still near each other, Mars passed Saturn and then Jupiter. This grouping of planets was something Kepler had never seen before and he set to work figuring out just how frequently it would occur. His calculations showed that Jupiter, Saturn, and Mars had figured in a similar grouping in 7 and 6 B.C. This is verified each year when the gears in many of our American planetariums are turned backward to show the stars and planets as they were placed nearly 2,000 years ago, at the time of Christ. Just as with Kepler's case, retrogression causes the two planets to separate for a time, but in 6 B.C. they are seen to approach each other again and to form a triangle with Mars. However, the sun is then very close to the triple conjunction, and its actual observation by the ancients must have been difficult.

It can be argued that a configuration of planets could never be mistaken for a star. This is very true, but many celestial objects are popularly referred to as stars which do not belong to that category. Venus, a planet, is called morning or evening star depending on whether it rises before the sun or sets after it, and so, also, are the other planets. Comets have been described as "long-haired stars." Thus, had the Magi observed this grouping of planets and interpreted it as the sign for which they were looking, in the telling of the story they might have referred to it as a star.

We have, then, these many possibilities, and others less plausible. Perhaps it is well that we cannot definitely say. Certainly this does not detract from the beauty of the thought nor does it dim the inspiration brought to men's hearts by the story of the Christmas star seen by the Magi long ago.

Comet de Kock, 1941c, photographed by Harvard's station in South Africa.

COSMOGONICAL IMPLICATIONS OF THE ATOMIC BOMB--II

By FELIX CERNUSCHI, *Guggenheim Fellow at Harvard University*

4. The fission of uranium

LAST MONTH we learned that the packing energy is calculated from the difference in the mass of the nucleus as a unit and the sum of the masses of its component neutrons and protons, taken separately. The ratio of this difference in mass, measured in units of mass (1/16 of the mass of the isotope of oxygen of mass number 16), and divided by A (number of protons plus number of neutrons in the nucleus) is called the *packing fraction*. For hydrogen the packing fraction is positive and very large (0.0078 mass units), but for helium it is very small (0.0005 mass units) as compared with the packing fractions of the light elements lithium, beryllium, and boron. This is true in spite of the fact that helium's mass number is only 4, whereas A for lithium is 6 and 7, for beryllium 8 and 9, and for boron 10 and 11. From this fact, one deduces that the alpha particle is very stable, and that two protons and two neutrons inside any nucleus may constitute a special unit. This is the reason some of the heavy radioactive elements emit alpha particles.

For elements in the periodic table up to neon, the packing fraction is positive, and from there on it is negative, reaching a minimum value for elements of medium atomic number, such as nickel, for which it is —0.0009 mass units. This is why elements such as iron, copper, and zinc are so stable, and very difficult to disrupt by artificial means. For the heaviest elements, the value of the packing fraction is positive, which is why most of them are radioactive and why some of them can be disrupted by neutrons.

Now let us briefly recount the discovery of the disruption of uranium nuclei when they are bombarded with neutrons. The first information of this extraordinary discovery appeared in a letter published in *Nature*[12] by Lise Meitner, of the Academy of Science of Stockholm, and O. R. Frisch, of the Institute of Theoretical Physics of Copenhagen. In this letter it is stated that O. Hahn and F. Strassmann, in Germany, had been continuing the experiments initiated by E. Fermi and his collaborators in Italy, and by I. Curie and P. Savitch in France. All these investigators were concerned with the study of the radioactive bodies formed from uranium under neutron bombardment.

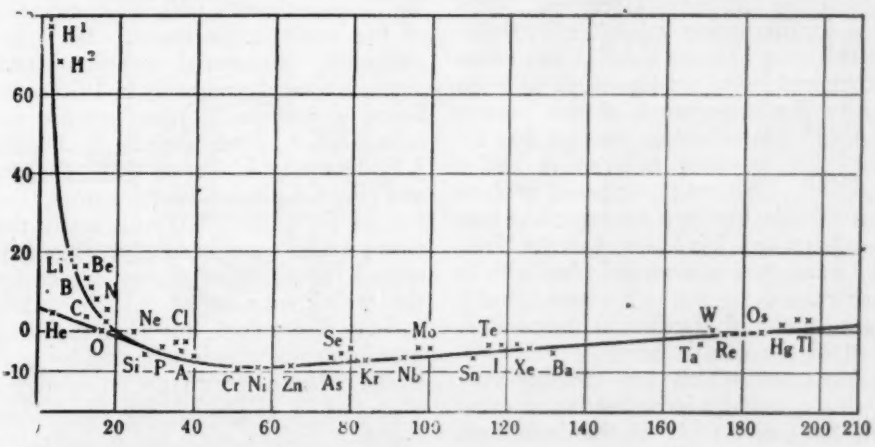
Fermi had found that at least four radioactive substances were produced, two of which were considered as having atomic number larger than 92; these elements were called *transuranic*. Hahn and Strassmann found that a group of at least three radioactive bodies, formed from uranium bombarded by neutrons, was chemically similar to barium and, therefore, presumably isotopic with radium. Further investigation showed that it was impossible to separate these elements from barium, so Hahn and Strassmann had to conclude that isotopes of barium ($Z = 56$) are formed as a consequence of the bombardment of uranium ($Z = 92$) with neutrons.

This result was not foreseen, for until that time it was thought that a nucleus could only emit particles with no charge, or with one or two charges, and that a nucleus could never be split into two nearly equal parts. This fact proved that the theory of nuclear physics was, as it is also today, behind the experiments. We still need some general principles which would permit the mathematical development of the consequences of nuclear bombardment under all possible circumstances. Meanwhile, we may expect further striking experimental discoveries in this exciting field.

The new effect discovered by Hahn and Strassmann was interpreted by Meitner, Frisch, and Bohr in the following way.[13] The billiard table model of a heavy nucleus is in some ways similar to a liquid drop. The surface tension which keeps the molecules of the drop bound together represents Gamow's potential barrier which holds neutrons and protons within the radius of the nucleus. If a new particle comes within the drop, it shares its energy with the other particles in the drop, and alternative events may occur.

If the surface tension is great in comparison with the binding energy of a single particle within the drop (this is the case of the light elements), it is more probable that after a time a particle near the surface of the drop will concentrate enough energy to escape. This evaporation of a single molecule from the drop may be likened to the emission of a single particle from the nucleus.

On the other hand, the surface tension may be relatively small, corresponding to the case of the heavy elements, where the number of positive charges creates large repulsive forces which reduce the effect of the nuclear attractive forces among the particles. In this case, the quasi-thermal distribution of the energy among the particles of the drop may be largely converted into some special mode of vibration of the drop involving a considerable deformation of the



Here the packing fractions of the elements are plotted against A. Except for helium, the elements lie on nearly a smooth curve. From a high positive value for hydrogen, the packing fraction decreases to a minimum for such elements as nickel and zinc; thence it increases slowly with atomic weight and becomes positive for the heaviest elements. The vertical axis scale is in 1/10,000 of a mass unit. From "Elements of Nuclear Physics," by Franco Rasetti, Prentice-Hall, Inc.

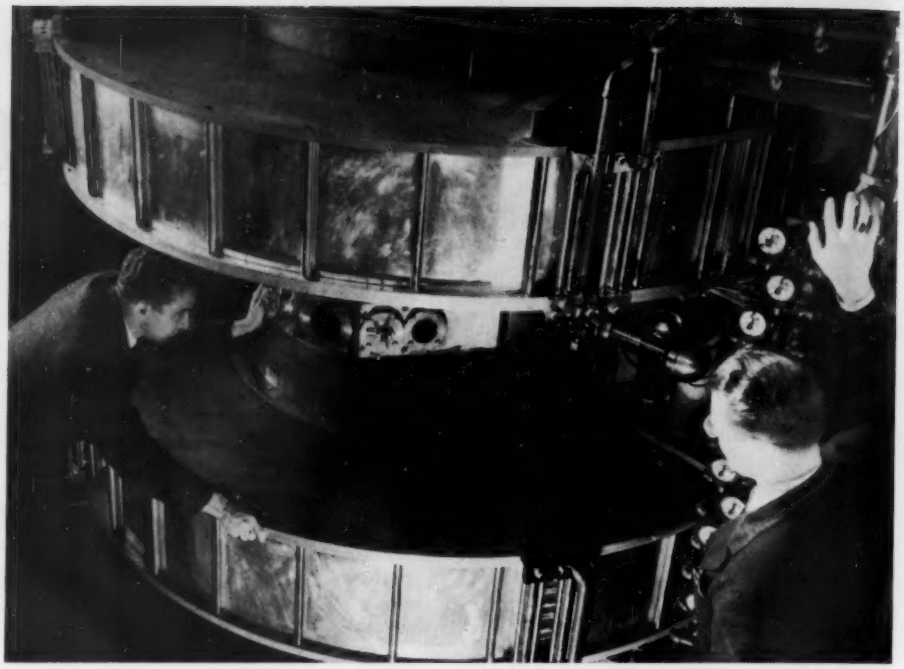
surface. When the surface is deformed, for instance into an ellipsoid, the longest radius may well exceed the size of the region in which Coulomb's law does not hold (see Section 3); the repulsive Coulomb forces will come into play and a fission of the nucleus into two nearly equal parts will take place.

Bohr and Wheeler later developed this theory further.[14] The compound system of bombarded nucleus and bombarding particle ($_{92}U^{239}$) is in general of long life, and the excitation energy of the bombarding particle becomes distributed over all degrees of freedom, as in thermodynamic equilibrium. The experiments of Ageno, Amaldi, Bocciarelli, and Trabacchi[15] have shown that the cross section for fission of uranium by neutron bombardment remains practically constant from about one million electron volts to about 10 million electron volts; then it increases considerably for higher energies, that is, the nucleus is much more susceptible to fission by high-energy neutrons, obtained by bombarding lithium with deuterons.

For the lower energy range, the ratio of the probabilities of the alternatives described above (particle emission or fission) is nearly constant, which is the way Bohr explains the constant cross section shown by the experiments. When the energy of the bombarding neutron is above 10 million e.v., however, in those cases where the intermediate $_{92}U^{239}$ emits a neutron and returns to its original $_{92}U^{238}$, the nucleus may be left with sufficient energy of excitation to undergo an explosion into two nuclei.

Therefore, the high-energy neutron carries so much energy into the nucleus that even though a neutron may be ejected from the intermediate system, fission will still take place. The condition for disruption is further favorable in this case because $_{92}U^{238}$ has even-numbered charge and mass. This leads us to the importance of the isotope $_{92}U^{235}$ (described in Section 3), for the addition of a neutron makes it $_{92}U^{236}$. This even-numbered nucleus has a critical energy for explosion into two parts which is lower than the binding energy of a neutron! And this is one reason for the importance of this rare isotope of uranium in the production of the atomic bomb.

Neutrons which are moving very fast are actually less effective in causing the fission of U^{235} than are slow-moving neutrons. The latter are called *thermal* neutrons because their velocities are as low as those of gas molecules at ordinary temperatures. Consequently, for U^{235} bombardment, fast neutrons may be slowed down by collisions with substances rich in hydrogen, such as paraffin or water. Unfortunately, U^{235} is present as only one part in 140 of an average sample of uranium.



A cyclotron, such as this 100-ton device at Massachusetts Institute of Technology, may be used to accelerate ions, usually deuterons, which in turn bombard lithium or beryllium to produce high-energy neutrons. Here, Dr. R. D. Evans is examining the port in the vacuum chamber from which the high-speed ions emerge. The M.I.T. cyclotron was built primarily to study problems of radioactivity related to biology and medicine.

Uranium normally splits into two unequal parts of mass numbers of the order of 140 and 90. Most of these products are unstable and decay by radioactive emissions into stable forms of lower masses. Fast neutrons can also split thorium and protoactinium, but the latter is a rare element and the former seems to have no advantage over uranium.

F. Joliot, in Paris, had been carrying on experiments without knowledge of the work in Germany. He independently discovered uranium and thorium fission, and early in 1939 published experimental proof of his results.[16] H. L. Anderson, E. T. Booth, J. R. Dunning, E. Fermi, G. N. Glasoe, and F. G. Slack[17] were among the first in the United States to verify the new process experimentally. They observed the pulses of energy caused by the well-known alpha-particle radioactivity of uranium, but when the same uranium oxide was bombarded by neutrons, pulses of very large energy were observed in addition. By comparing the new pulses with those from the alpha particles, the energies of the fission products were estimated to range up to about 90 million electron volts. Theory and further experiment agree that the total energy released in uranium fission is of the order of 200 million e. v., which is the source of the atomic bomb's devastating power.†

A meeting of theoretical physicists was held in Washington, D. C., on January 26, 1939, organized by George Washington University and the Carnegie Institution of Washington. Enrico Fermi, whom fascism drove from Italy and who was then working at Columbia University, and Niels Bohr, visiting professor at Princeton University, led the discussion of the interpretation and possibilities of the newly discovered fission process. Fermi was the first to suggest the possibility that a chain reaction could result from the fission process and eventually lead to an explosion of nearly the whole mass of U^{235} present in a sample. In Fermi's guess is the origin of the atomic bomb and the possible utilization of the extraordinary energy of the nuclei for industrial and other peaceful purposes.

As the products of uranium fission decay radioactively, neutrons are emitted along with beta particles. The average number of neutrons released from a split uranium atom is between one and three, and the maintenance of a chain reaction would require that each fission produce enough useful neutrons to maintain a series of fissions. Many neutrons are bound to be lost, and others may not produce fission. The investigations carried on

†For a complete account of the status of nuclear fission up to 1940, the reader should consult the excellent review by L. A. Turner in the *Review of Modern Physics, 12,* 150, 1940.

in the United States in connection with the atomic bomb have proved that the chain reaction suggested by Fermi was indeed possible.

5. The atomic bomb is born

AT THE REQUEST of Major General L. R. Groves and on behalf of the government of the United States, Professor H. D. Smyth, chairman of the department of physics of Princeton University and consultant to the Manhattan District project, has written a complete report of the development of the atomic bomb.[18] It contains the details of the scientific theory and problems involved as well as a full account of the organization of governmental, industrial, and scientific agencies and personnel in the most mammoth single effort of the war. It is not necessary for us to repeat what is so lucidly presented in the Smyth report, and every reader is urged to read it from cover to cover. Some of the following discussion, however, follows the Smyth presentation closely and is included here for its bearing on our general consideration of the subject of nuclear fission.

At the beginning of the atomic bomb development, fundamental researches were carried on in various laboratories of universities and other scientific institutions. In 1942, under the direction of Arthur H. Compton, a group at the University of Chicago organized a "metallurgical laboratory" devoted exclusively to the atomic bomb project.

In November of that same year, an atomic bomb laboratory was secretly constructed at Los Alamos, N. M., about 20 miles from Santa Fe. It was a very isolated site and had an extensive area in which experiments on the bomb could be safely carried on. J. R. Oppenheimer, professor of theoretical physics at the University of California, was made director of the new laboratory, and he succeeded, with the help of General Groves and James B. Conant, in forming around him a dense cluster of bright scientists from many universities. The difficulties which had to be surmounted to install this laboratory in such an inaccessible place, with all the necessary machines, instruments, apparatus, and materials, were extraordinary.

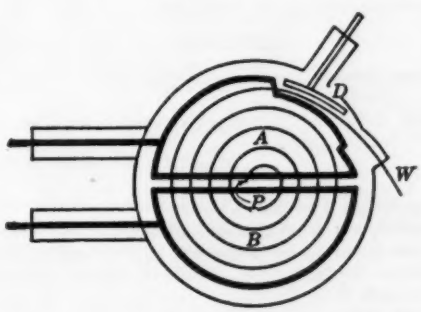
The atomic bomb, the most fantastic and in some ways the most terrific of all human inventions, was the result of amazing teamwork, integrated by thousands of persons and perfectly coordinated by a group of the most brilliant scientists in the world. The cost of the entire project was about two billion dollars.

Also at the end of 1942, it was decided to construct a plant of intermediate size to produce the materials needed for experimental research on the heavy elements. This plant was built at Clinton, Tenn., and known as the Clinton Engineer Works. Chosen for the available power supply, the site was not considered isolated enough for mass production of radioactive substances. Therefore, on the west side of the Columbia River, north of Pasco, Wash., the government selected an area of 200 square miles for the construction of a huge plant called the Hanford Engineer Works. This place was well isolated, yet near the Grand Coulee power line and the waters of the Columbia River. In 1944, at maximum activity, Hanford had a population of 60,000.

6. By-products of the program

AS A RESULT of atomic bomb research, the future holds promise of the discovery of new nuclear reactions of even greater efficiency, and this new source of energy can be easily turned to the benefit of mankind. In 1944, General Groves appointed a special committee to study carefully the possible peaceful uses of nuclear energy. At this writing, this committee had not published the results of its studies, but A. L. Baker, general manager of the Kellex Corporation of Oak Ridge, Tenn., which worked on the bomb, has pointed out through Science Service that the atomic bomb project gave the following beneficial by-products:

(1) Cheaper and more abundant sources of radioactivity in the treatment of cancer. (2) Improved methods to overcome industrial risks due to the presence of poisonous substances. (3) Improvement in high-vacuum technique which can be employed in the low-temperature dehydration of foods. (4) Improvements in vacuum distillation for the production of vitamins. (5) New methods to fractionate gasoline and more efficient mass-spectrum analysis for the petroleum industry. (6) New electronic techniques. (7) More efficient gas pumps (some of those developed for the atomic bomb can deliver a stream of gas at a velocity exceeding that of sound).



The cyclotron vacuum chamber contains two D-shaped electrodes, A and B, known as dees. These receive high-frequency alternating current, the energy to accelerate charged particles introduced at the center. The particles spiral outward and emerge from a port W, like that in the photograph of the M.I.T. cyclotron opposite. From "Applied Nuclear Physics," by Pollard and Davidson.

Some five thousand new or improved products and techniques will be available to American industry when the government releases the corresponding methods for mass production. In 20 years the improvements in gas pumps alone will produce benefits worth the total expense for the atomic bomb project.

Perhaps a possible industrial application of the processes of the atomic bomb would be to construct a pile similar to that used in the bomb, but with water instead of graphite as a moderator, in which case the fast neutrons would increase the mean velocity of the molecules, and consequently the temperature of the water. The process might be regulated in such a way that when the water vapor acquired a certain temperature, the multiplication factor (chain reaction effect) would decrease, making a self-regulating boiler. The writer does not know of any experiments along this line, so he cannot say that such a process is really possible.

The writer, further, has suggested to Professor Smyth the following application of the atomic bomb itself. The best way to obtain useful information regarding the internal constitution of the earth is by means of earthquakes. But it is extremely difficult to know accurately the point of origin of an earthquake, the energy used and evolved in its production, and the exact time at which it begins. All these difficulties would disappear by producing artificial earthquakes with atomic bombs in selected places on the earth at different times.

Out of such a project, it might well be possible to gain a complete knowledge of the distribution of mineral wealth beneath the surface of the earth, which would be of extreme importance to increase the useful sources of raw material for the welfare of the human race. On the other hand, by knowing accurately the constitution of the earth, as revealed by such artificial earthquakes, we should be able to better picture the initial conditions of the formation of the earth and of the solar system.

An artificial earthquake program could be organized and carried on by scientists belonging to all the nations of the world—a useful international

(Continued on page 15)

Astronomical Observatories

By Mabel Sterns, *National Ca*

I HAVE TRIED to learn of as many as possible of the astronomical observatories in the United States, defining an observatory as a building designed or adapted to house a telescope permanently mounted. The list is not complete, I am sure, and I hope readers will volunteer additions and corrections. If demand warrants, the list will be published separately, revised, and with another classification added.

To avoid the proportions of a book, information in this list has been kept at a minimum. There are several works available which contain descriptions of the larger observatories, and the present effort is not intended to duplicate them, but rather to show the number and distribution of observatories, both professional and amateur.

Of these 273 observatories, some have been inactive for the duration

ALABAMA

Tuscaloosa: Univ. of Alabama

ARIZONA

Flagstaff: Lowell Obs.
Tucson: Steward Obs., Univ. of Arizona

ARKANSAS

Monticello: Adrian Williamson

CALIFORNIA

Angwin: Newton Astronomical Obs., Pacific Union College
Berkeley: Clarence Parham, Sr.
Students Obs., Univ. of California
Franklin B. Wright
Claremont: Frank P. Brackett Obs., Pomona College
Coleville: Mono Astrophysical and Meteorological Obs.
Corte Madera: Charles Fischer
Escondido: Clarence Friend
Los Angeles: Griffith Obs.
Frederick H. Minard
Edward Hayes Morse Memorial Obs., Occidental College
Mare Island: Chronometer and Time Service, Navy Yard
Montrose: La Crescenta Obs.
Mount Hamilton: Lick Obs., Univ. of California
Mount Palomar: Astrophysical Obs. of the California Institute of Technology
Mount Wilson: Mount Wilson Obs., Carnegie Institution of Washington
National City: John Gardner
Oakland: Chabot Obs., Oakland Public Schools
Pasadena: Pasadena Junior College
Sacramento: Charles A. Fogus
San Diego: Astronomical Society of San Diego
Wendell Brant
Carl Dickson
R. M. Lippert
C. A. and H. A. Lower
Al Nelson
F. Robinett
San Diego State Teachers College
George Sharp
San Francisco: Davidson Obs.
San Leandro: George F. Tauchmann
Santa Barbara: L. S. Copeland
Santa Clara: Ricard Memorial Obs., Univ. of Santa Clara
Stockton: College of the Pacific,
Tulare: A. L. Pursell and Fred Peterson
Ukiah: International Latitude Obs., U. S. Coast and Geodetic Survey
Wrightwood (Table Mountain): Solar Station, Smithsonian Astrophysical Obs.

COLORADO

Berthoud: John Bunyan
Denver: Chamberlin Obs., Univ. of Denver
Edgewater: Anton Bohm
Fremont Pass: Climax Station, Harvard College Obs.

CONNECTICUT

Greenwich: Edgewood School
Hartford: Trinity College
Middletown: Van Vleck Obs., Wesleyan Univ.
New Canaan: John E. Lancaster
New Haven: Yale Univ.
Norwalk: Richard W. Hamilton

DISTRICT OF COLUMBIA

Georgetown: Georgetown College Obs., Georgetown Univ.
Washington: United States Naval Obs., Navy Department

FLORIDA

Coral Gables: James J. Marshall
Daniel H. Redfearn
Daytona Beach: Daytona Beach Astronomical Society
Miami: Richard A. Belsham
Lynn C. Burkhart
J. P. Pena
A. P. Smith, Jr.
Southern Cross Obs., Southern Cross Astronomical Society
Miami Beach: Gar Wood
St. Petersburg: T. C. H. Bouton

GEORGIA

Griffin: P. O. Parker

ILLINOIS

Chicago: Chicago Univ.
Elgin: Elgin Obs.
Evanston: Dearborn Obs., Northwestern Univ.
Galesburg: Knox College
Moline: Sky Ridge Obs., Carl H. Gamble
Park Ridge: Charles F. Pope
Peru: Hamilton Maze
Springfield: Frederick C. Holtz
Techny: St. Mary's Major Seminary
Urbana: Univ. of Illinois
Wheaton: Alumni Obs., Wheaton College

INDIANA

Bloomington: Kirkwood Obs., Univ. of Indiana
Brooklyn: Goethe Link Obs.
Crawfordsville: Jewell Obs., Wabash College
Greencastle: McKim Obs., DePauw Univ.
Hanover: Hanover College
Indianapolis: Indiana Astronomical Society
Notre Dame: St. Mary's College
Richmond: Earlham College

IOWA

Des Moines: Drake Univ. Municipal Obs.
E. N. Manbeck, Jr.
Fairfield: Parsons College
Iowa City: Univ. of Iowa

KANSAS

Hays: Fort Hays Kansas State College
Lawrence: Univ. of Kansas
Pittsburg: Kansas State Teachers College
Topeka: Zenas Crane Obs., Washburn College

KENTUCKY

Coral Ridge: W. L. Moore
Lexington: Univ. of Kentucky

LOUISIANA

Baton Rouge: David V. Guthrie Obs., Louisiana State Univ.
New Orleans. Thomas F. Cunningham Obs., Tulane Univ.

MAINE

Brunswick: Bowdoin College
Farmington: Alphonse Ibarguen
Kennebunk: R. G. Stephens
Orono: Students Obs., Univ. of Maine
Portland: R. F. Bennett
Saco: Deering Obs., Thornton Academy
South Portland: Terraceleste, Herbert M. Harris
Waterville: Colby Obs., Colby College

MARYLAND

Baltimore: Johns Hopkins Univ.
Maryland Academy of Sciences
Joseph L. Woods
Bethany: Bethany College
Cumberland: Allegheny High School
Harry Footer
G. F. Hofferberth
T. L. Richards
Frederick: Williams Astronomical Obs., Hood College
Gaithersburg: International Latitude Obs., U. S. Coast and Geodetic Survey
Westminster: Western Maryland College
Woodstock: Woodstock College

MASSACHUSETTS

Amherst: Lawrence Obs., Amherst College
Boston: Boston Univ.
Cambridge: Harvard College Obs., Harvard Univ.
Students Obs., Radcliffe College
Harvard: Oak Ridge Station, Harvard College Obs.
Nantucket: Maria Mitchell Obs.
Newton: Frank A. Jasset
Northampton: Smith College
Pittsfield: Dr. Camilli
South Hadley: John Payson Williston Obs., Mt. Holyoke College
Wellesley: Whitin Obs., Wellesley College
Williamstown: Hopkins Obs., Williams College

MICHIGAN

Ann Arbor: Dr. Merrill
Univ. of Michigan
Benton Harbor: H. B. Ross
Bloomfield Hills: Cranbrook Institute of Science
Detroit: Max Bartholomew
Howard C. Buck
Wayne Univ.
Lake Angelus: McMath-Hulbert Obs., Univ. of Michigan
Roseville: Robert Sandberg
Wayne: Claude B. Carpenter
Ypsilanti: State Normal College

MINNESOTA

Duluth: Duluth Obs., State Teachers College
Minneapolis: Univ. of Minnesota
Northfield: Goodsell Obs., Carleton College
Payne: Amateurs of Science

tors in the United States

al Cap Amateur Astronomers Association

of the war. It is odd that only one is named for a woman, and another owned by a member of the fair sex. There are 42 states represented, plus the District of Columbia.

I am grateful to friends and amateur societies and individuals throughout the country for their help and suggestions. Mrs. G. O. Savage and Mrs. Lois W. Bendigo, of the U. S. Naval Observatory, as well as the Library of Congress, gave their assistance. Among other references may be noted: "Amateur Telescope Making Advanced," "American Ephemeris and Nautical Almanac 1946," "American Universities and Colleges," "Index Generalis," "Les Observatoires Astronomiques," "Scientific American," and "Sky and Telescope."

MABEL STERNS
2517 K St., N.W.
Washington 7, D. C.

MISSISSIPPI

Jackson: James Obs., Millsaps College
Oxford: Univ. of Mississippi

MISSOURI

Columbia: Laws Obs., Univ. of Missouri
Fayette: Morrison Obs., Central College
Parkville: Charles Smith Scott Obs., Park College
St. Louis: St. Louis Univ.
Washington Univ.

NEBRASKA

Crete: Boswell Obs., Doane College
Lincoln: Rose Memorial Obs., Nebraska Wesleyan Univ.
Univ. of Nebraska
Omaha: Creighton Univ.

NEVADA

Carson City: Mrs. Marion Grant Bowen
Reno: C. H. Gorman

NEW HAMPSHIRE

Hanover: Shattuck Obs., Dartmouth College

NEW JERSEY

New Brunswick: Schanck Obs., Rutgers College
East Orange: David B. Pickering
Leonia: Waldo Obs.
Princeton: Princeton Univ.
Teaneck: Teaneck Obs., Bergen County Astronomical Society

NEW MEXICO

Tyrone (Burro Mountain): Solar Station, Smithsonian Astrophysical Obs.

NEW YORK

Albany: Dudley Obs.
Annandale-on-Hudson: Bard College
Aurora: Wells College
Brooklyn: Brooklyn College
Brooklyn Institute of Arts and Sciences
Buffalo: Kellogg Obs., Buffalo Museum of Science
Clinton: Litchfield Obs., Hamilton College
Elmira: Elmira College
Geneva: Smith Obs., Hobart College
Hewlitt: Lawrence School
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Lynbrook: Harold B. Webb
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Hiram: Stephens Memorial Obs., Hiram College
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Marietta: Gurley Obs., Marietta College
Miamitown: Stewart Obs., Cincinnati Astronomical Society
Oberlin: Oberlin College
Springfield: Edgar Weaver Obs., Wittenberg College
Toledo: University Obs., Univ. of Toledo
Trenton: C. J. Renner
Wilmington: Wilmington College
Wooster: Wooster College

OKLAHOMA

Norman: Univ. of Oklahoma

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Eugene: Evergreen Obs., J. Hugh Pruett
McMinnville: Linfield College
Portland: Robert E. Millard
Salem: B. L. Bradley

PENNSYLVANIA

Beaver: Roelof Weertman
Berwyn: Tredyffrin Obs., H. B. Rumrill
Bethlehem: Lehigh Univ.
Chambersburg: Wilson College
Greensburg: Seton Hill College
Haverford: Strawbridge Memorial Obs., Haverford College
Lancaster: Daniel Scholl Obs., Franklin & Marshall College
Lewisburg: Bucknell Univ.
Meadville: Newton Obs., Allegheny College
Philadelphia: The Franklin Institute
Pittsburgh: Allegheny Obs., Univ. of Pittsburgh
North Star Obs., David L. Brown
People's Obs., Buhl Planetarium and Institute of Popular Science
Rosslyn Farms Obs., Roy Hoffman
Sterrett School Obs., Board of Education
Valley View Obs., Leo Scanlon
South Bethlehem: Sayre Obs., Lehigh Univ.
State College: State College Obs.
Swarthmore: Sproul Obs., Swarthmore College
Upper Darby: Flower Obs., Univ. of Pennsylvania
Warren: R. W. Steber
Wynnewood: Cook Obs., Univ. of Pennsylvania

RHODE ISLAND

Jamestown: Spraycliffe Obs.
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Providence: Ladd Obs., Brown Univ.

SOUTH CAROLINA

Columbia: Melton Memorial Obs., Univ. of South Carolina
Gilbert G. Pike

SOUTH DAKOTA

Redfield: Redfield College
Vermillion: McKinney Obs., Univ. of South Dakota
Yankton: Yankton College

TENNESSEE

Chattanooga: Chattanooga Astronomical Obs., Univ. of Chattanooga
McCallie School
East Nashville: Latimer J. Wilson
Jefferson City: Carson-Newman College
Mayland: L. L. Rice
Nashville: Barnard Obs., Vanderbilt Univ.

TEXAS

Dallas: Blanton Astronomical Obs., Southern Methodist Univ.
Fort Worth: Las Estrellas Obs., Texas Observers
Fort Davis (Mount Locke): W. J. McDonald Astronomical Obs., Universities of Texas and Chicago
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Salt Lake City: Univ. of Utah

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Middlebury: Middlebury College and the Women's College of Middlebury
Morrisville: Grout Obs., School Board
Springfield: Stellafane, Springfield Telescope Makers.
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Winooski Park: Holcomb Obs., St. Michael's College

VIRGINIA

Charlottesville: Leander McCormick Obs., Univ. of Virginia
Harrisonburg: Vesper Heights Obs., Eastern Mennonite School

WASHINGTON

Seattle: Univ. of Washington
Tacoma: Croston
Yakima: Fred Farmer

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Lewisburg: The Cliffs Obs., Morgan Cilley

WISCONSIN

Appleton: Underwood Obs., Lawrence College
Beloit: Smith Obs., Beloit College
Madison: Washburn Obs., Univ. of Wisconsin
Marshfield: K. F. Davidson
Milwaukee: Milwaukee Astronomical Society
Oshkosh: Ralph N. Buckstaff
Superior: Wisconsin State Teachers College
West De Pere: St. Norbert College
Williams Bay: Yerkes Obs., Univ. of Chicago

Amateur Astronomers

THIS MONTH'S LECTURES

Detroit: The December meeting of the Detroit Astronomical Society will be held at Wayne University, Room 17, on the 9th, Sunday, at 3:00 p.m., when Dr. Hazel Losh, University of Michigan, will speak on "Sunspots and Terrestrial Phenomena."

Indianapolis: "Winter Skies" will be discussed by Paul Richey at the December 2nd meeting of the Indiana Astronomical Society, held at 2:15 p.m. at Odeon Hall.

New York: Dr. Herbert J. Spinden, of the Brooklyn Museum, will speak on "Astronomy of the Maya Indians," to the Amateur Astronomers Association. The meeting is at 8:00 p.m. Wednesday, December 5th, in the Roosevelt Memorial building of the American Museum of Natural History.

Pittsburgh: "The Geology of Western Pennsylvania" is the subject of the December 14th lecture to the Amateur Astronomers Association of Pittsburgh. John Goodman, chief geologist of the Equitable Gas Co., Pittsburgh, is the speaker, and the meeting will be at the Buhl Planetarium.

Washington, D. C.: At the meeting of the National Capital Amateur Astronomers Association on Saturday, December 1st, Dr. Irvine C. Gardner, chief of the Optical Instruments Section, National Bureau of Standards, will speak on "Eclipses." The meeting is at 8:00 p.m. at the National Museum.

Worcester: Dr. Bart J. Bok, of Harvard Observatory, will lecture before the Aldrich Astronomy Club on "The Milky Way," on December 13th, Thursday, at 8 o'clock in the Worcester Natural History Museum.

FOX VALLEY ASTRONOMICAL SOCIETY

A letter from Dr. Frank Hancock reports that amateur astronomers have formed the Fox Valley Astronomical Society. Officers are: president, Frank Hancock, Geneva, Ill.; vice-president, Harry M. Coultrap, Geneva; secretary-treasurer, William Siekman, Batavia, Ill.; with an advisory committee composed of Carl P. Bast, Batavia; Professor Clarence R. Smith, Aurora, Ill.; William King, Geneva; and Frank Lentz and Joseph Zoda, both of St. Charles, Ill.

There was also formed a telescope making committee with Gus Eberman as chairman and instructor, and Messrs. Lentz, Zoda, and Herbert Spieler, Jr., as members.

Meetings are to be held monthly through the winter season, the place to be announced. Communications may be addressed to Mr. William Siekman, Woodlawn Ave., Batavia, Ill.

A PLANETARIUM FOR WASHINGTON?

A model of a planetarium is included in the model of postwar Washington, on view at the Corcoran Art Gallery, reports *Star Dust,* bulletin of the N.C.A.A.A. Apparently, the Parks and Planning Commission has no information on how the planetarium came to be included in the model, nor when or how it will be financed and constructed.

STEPHEN NAGY DIES

From *Star Dust,* we learn of the untimely death, on September 28th, of Stephen Nagy, well-known Washington amateur.

Mr. Nagy was first president of the N.C.A.A.A., in which capacity he led that society's activities for five years. As an optical worker in the Navy Yard, he became adept at telescope making and conducted many classes in mirror grinding. He also led observing parties, and was active in planning the Third National Convention of Amateur Astronomers in Washington in July, 1941. In 1942, Mr. Nagy's work took him to Chicago, but amateur astronomy remained a prime interest with him. He also counted music, painting, microscopy, and photography among his hobbies.

DECEMBER ACTIVITIES

Chicago: The Burnham Astronomical Society will meet on Tuesday, December 11th, at 8:00 p.m. in the Chicago Academy of Sciences auditorium. The program includes a short talk on the December evening sky, by Miss Winifred Sawtell; a general discussion of "The Star of Bethlehem"; a Question Box; and, by Charles F. Graham, "The Story of My Eclipse Expedition." A number of telescopes made by members this past summer will be on exhibit in the lobby of the academy.

Cincinnati: The annual dinner meeting of the Cincinnati Astronomical Association is scheduled for Thursday, December 13th. For details, get in touch with Mr. Dan McCarthy, 1622 DeSales Lane.

Cleveland: At the Warner and Swasey Observatory, on December 7th at 8 o'clock, the Cleveland Astronomical Society will hold a Christmas party with an astronomical program.

Madison: After hearing a short talk on the constellation of Taurus, the Madison Astronomical Society will participate in a discussion of the solar system, with Dr. J. H. Gieselman acting as discussion leader. The meeting is on December 12th, at the Washburn Observatory, 8:00 p.m.

THE HEALTHY LIFE!

Mortality among astronomers is 20 per cent under that of the general public and only five per cent above that of ministers, according to an article by Helen C. Bennett, in *This Week* magazine for October 21st. Insurance actuaries say that ministers are about tops in longevity, and astronomers come next.

OCTOBER FIREBALLS

Meteor observing despite the full moon paid dividends to a group of amateur astronomers from New York City who journeyed to Yonkers to watch the Orionids on the night of October 20-21. Edward Oravec writes as follows:

"We began observing at 12:30 a.m. In the first hour I saw eight meteors, but then the rate fell off and several observers became discouraged and went indoors. Four of us stayed out and our expectations were exceeded beyond our wildest dreams when a fireball appeared low in the southwestern sky at 2:59 a.m. Bruce Stowe, whose house was our headquarters, saw it first and his frantic cry brought our attention to it.

"The fireball first appeared to me in Canis Major, magnitude about —6, and as it dropped low behind a house its brightness exceeded —11, or nearly the equal of the full moon. The head was large, and seemed to have two distinct parts—a central bright part and lighter coma ½-degree on either side. It was quite red, with some green in the head. When it had gone behind the house, it exploded and filled nearly half the sky with a reddish light. There was no persistent train and no noise was heard. All four of us, including Edward Waldmann, of Brooklyn, and Herbert Weiner, from the Bronx, sent reports to the American Meteor Society."

This fireball was reported in the next day's papers as the brightest seen in recent years, although it is doubtful that it was brighter than the "mysterious blast of May 4th" this year (see **Sky and Telescope,** 44, page 10).

A report has also been received from G. R. Staples, Portsmouth, Va., of his observation of two bright Orionids. One was seen on October 19th, at 9:05 p.m., of approximately —2.0 magnitude, a few degrees NNE of Deneb; and the other, of —3.5 magnitude, was seen on the 21st at 9:09 p.m., passing close to the north star. Both were swift and yellow, characteristic of the Orionids.

ASTRONOMICAL ANECDOTES

THE GREAT PATTEN METEOR AGAIN; SKY TRAILS

YEAR'S END is a good time to clean up past items, where possible. At the conclusion of 72 months of preparing these notes, I can express at least mild amazement that many readers of *Sky and Telescope* have written to say nice things about them. On occasion I've volunteered to discontinue, and some day the press of other duties may make that necessary; until then, however, thanks for not demanding that the column disappear.

According to Dr. James C. Bartlett, Jr., of Baltimore, I'll not have the ton of meteorite that I have momentarily been expecting to arrive, after the August story of the great Patten affair. Dr. Bartlett is one of those who "knew him when" at the Maryland Academy of Sciences. Poor Mr. Patten seems to have been a victim of a cruel and expensive hoax that, says Dr. Bartlett, could not be proved to be one. With that matter of proof I can hardly agree; surely there must have been some honest official in the neighborhood of the supposed workings who could have been asked for a report, even though Mr. Patten was too old to make the journey to the mine site himself. If it was believed at the Academy that the numerous photographs of the workings sent to Mr. Patten by his agents in the west were simply photos of ordinary copper and silver mines common to that region, an official inquiry could have settled the matter.

Dr. Bartlett reports that until Mr. Patten's death in 1925 or 1926, he scraped together every possible penny of his own and of investors in his project, continuing to support what appeared to be a hopeless venture. At no time did the Maryland Academy of Sciences sponsor the Patten Meteor Company or encourage donations to it. All of which leaves the latest 20 years still a mystery as far as the search for the meteorite is concerned.

Back in May, the editor forwarded to me a letter from Carl P. Richards, of Salem, Ore., who as of August 4th sent another on the same topic. The first letter concerned the cover illustration of this magazine for April, showing Venus setting, as photographed by Dr. Bart J. Bok from Tonanzintla. The trail of the planet is slightly curved; from the amount and direction of the curvature on such a picture, Mr. Richards likes to estimate the declination of the object at the time. The August issue, also on its front cover, shows the rising sun passing through eclipse, photographed by the Milwaukee Astronomical Society, and there, as Mr. Richards points out, the curvature is much stronger and in the opposite direction. Venus on January 29, 1945, had a declination of about —2°, while the sun on July 9th was at +22°.

The eclipse of the moon sequence reproduced in the November, 1938, issue of The SKY was made with the moon in declination —20°, so the diurnal path is curved about as much as that of the sun on July 9, 1945, but in the opposite direction. Very careful measurement, after dabbling a little with the theory, would probably enable the declination to be derived from the degree of curvature.

Mr. Richards sent some pictures he has made, one of them of Venus setting in April, 1940, when the declination exceeded +26°; others show the circular polar trails of stars, and the trails of the Orion stars, straddling the equator. In the latter picture, it is easy to see the northward concavity of the trails of the stars north of the equator, the straight trail of Mintaka, and the southward concavity of Rigel and Saiph, both below the equator. As the Oregon amateur says, there is nothing very remarkable about this but it has a distinct educational value in rendering more evident the apparent motions of objects in the sky.

If an object is on the celestial equator, its diurnal path is a great circle which, when it is photographed, is a straight line. Conversely, a straight line projected against the sky marks out a great circle. Sometime look at the sun and the moon at first quarter phase, at about three o'clock in the afternoon. The terminator seems to

Venus setting, 9:10 to 10:45 p.m., April 21, 1940. Photo by Carl P. Richards.

lie at such an angle that it appears to be impossible for the sun to be the source of the illumination. The error involved is in drawing, mentally, an almucantar—good old-fashioned word for a circle parallel to the horizon—joining the sun and moon, instead of a great circle. By holding a long staff at some distance, or having someone else hold it, in such a position that one end of it appears to pass through the center of the sun and the other through the center of the moon, it will become at once evident that the terminator *is* perpendicular to a line joining sun and moon, and that all's right with the universe. The eye should follow along a great circle in joining the sun and the moon, not along a small circle such as an almucantar.

But now, to return to the cover illustration for the August issue. Did Mr. Richards notice that the total phase is not on the arc with the others? There is probably a good explanation of this, for it is hardly a natural phenomenon; I have my own theory about it, involving alertness on the part of the photographer but lack of a rigid mounting on the part of the camera.

R. K. M.

COSMOGONICAL IMPLICATIONS OF THE ATOMIC BOMB

(Continued from page 11)

scientific enterprise.

By precipitating peace, the atomic bomb has saved more than a million Allied lives. Furthermore, this new weapon makes completely obsolete most of the known military weapons; consequently, the armies of small nations are rendered impotent, for at present only large nations can make atomic bombs. There is now no reason for a small nation to keep an army; it would do much better to invest money now in military budgets to improve educational, social, and scientific welfare. Now the great democracies have a formidable weapon to forestall future possibilities of war anywhere in the world. But here we do not wish to analyze the social repercussions of the atomic bomb. Nevertheless, we do think it is the duty of every citizen of every democracy to think carefully on this subject to enable him to make wise political decisions.

(To be continued)

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BOOKS AND THE SKY

OPTICAL INSTRUMENTS

Earle B. Brown. Chemical Publishing Company, Brooklyn, N. Y., 1945. 567 pages. $10.00.

OPTICAL INSTRUMENTS is a book in which the author, as he states in the introduction, "has attempted to present the broad field of optical instruments as a related whole and to prepare a volume which will be of value and interest to students and teachers in schools and industrial plants, personnel of military and civil establishments, workers and repairmen whose occupation has brought them into contact with various types of optical instruments which it would be to their interest and advantage to understand. The material has been organized so as to make it possible to use the volume as the text for a course in 'Familiarization with Optical Instruments,' although this is not its principal purpose." The book, however, "is not intended for the optical or mechanical engineer, nor as a manual of instruction for the use and care of any particular instrument." In achieving its stated purpose, **Optical Instruments** has in many respects been quite successful.

For purposes of presentation of his subject, Mr. Brown has divided the broad field of optical instruments into four sections: I. Principles of Geometrical Optics, II. Description, Operation and Theory of Optical Instruments, III. Construction and Maintenance of Optical Instruments, IV. Supplementary Topics.

Under the first of these headings are quite thoroughly discussed such subjects as the refraction of light by lenses and various types of prisms, and the reflection of light from surfaces. Focal properties, imagery, and magnification are developed for both thick and thin lenses, and simple formulae are worked out to describe mathematically the several relationships involved. The various aberrations of lenses and the effects of diaphragms and stops in optical systems are described. There are interesting sections on types of achromatic objectives and on a number of types of eyepieces.

The second part deals at considerable length with the construction and use of the telescope, camera, microscope, field glass and binocular, projector, theodolite, spectroscope, and various military instruments and range finders, all from the descriptive rather than the mathematical point of view.

Anyone interested in optical devices will find Part III of great value, as a number of methods employed in the manufacture, assembling and testing of optical instruments are described. This section includes also the care, cleaning and maintenance of such instruments.

In the last section the author makes a few comments on the problems of designing an optical system of given specifications, the manufacture of optical glass, and certain topics selected from the field of physical optics. In the reviewer's opinion the section on physical optics might advantageously have been expanded to deal at greater length with the subjects treated, and might well have included more topics.

Unfortunately, this book is marred by frequently inexact, ambiguous or, at times, incorrect statements. These cannot be listed in detail here, but a few examples from the chapter on the spectroscope will indicate the kind of errors to be expected.

On page 307 the theoretical resolving powers of prisms and gratings are defined by formulas which are the reciprocals of those in common usage. The formula for the resolving power of a prism as defined by Mr. Brown contains a mathematical error.

On page 308, it is stated, "Prism spectrographs to work in the infrared and ultraviolet must be made with fused quartz or fluorite prisms and optical elements, due to the opacity of the glass, especially for the ultraviolet." Up to the present time, owing to the high melting point of quartz, it has not been possible to melt it thoroughly enough to eliminate all the bubbles and inhomogeneities in pieces of fused quartz of sufficient size to be used in any except the smallest instruments where the optical path through the quartz is not much in excess of a centimeter. In the finest and in all the

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larger quartz spectrographs the optical parts are made of crystalline quartz.

The author's confusion of fused quartz with crystalline continues as he discusses the double refraction and the polarization of light by quartz crystals. Fused quartz is isotropic and does not possess the properties of double refraction and rotary polarization Mr. Brown ascribes to it. Prisms cut from crystalline quartz have these properties, however, and not only must the optic axis of the crystal be parallel to the base of the prism, but provision must also be made to counteract the rotary polarization.

On page 311, it is stated that air is opaque to wave lengths shorter than 2900 angstroms, but in reality this cutoff begins at about 1850 angstroms. The author may have had in mind the astronomical extinction of incoming radiation, but this is caused by ozone absorption in the high layers of the atmosphere. He also calls the region below 2900 angstroms "near X-ray," whereas this is really the near ultraviolet. The X-ray region is difficult to delimit precisely, but it is probably correct to say that it extends from about 1000 angstroms to 0.01 angstrom.

The index of **Optical Instruments** is worthy of comment. It is remarkably complete and should enable anyone to find readily the precise information in the book which he desires.

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ATOM SMASHERS. *Raymond F. Yates*, 1945. *Didier*. 182 pages. $2.00.

A popular account of some of the historical background leading up to the current status of research in nuclear physics, and covering the various experiments in many countries which have led to our present knowledge of the use of atomic power.

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PLANETARIUM NOTES

Sky and Telescope is official bulletin of the Hayden Planetarium, 81st Street and Central Park West, New York City, and of the Buhl Planetarium, Federal and West Ohio Streets, Pittsburgh, Pa.

★ **THE BUHL PLANETARIUM** presents in *December*, THE WISE MEN'S STAR. (See page 7.)

The Star of Bethlehem—what could it have been? Was it a brilliant comet the Magi and shepherds saw? Or a bright meteor? Or an extraordinary grouping of planets which occurred about the time Christ was born? It is a mystery which may never be solved. But the magic of the planetarium projector takes visitors during December back to Palestine's skies of 2,000 years ago, to view the astronomical possibilities for that first of all Christmas stars.

★ **THE HAYDEN PLANETARIUM** presents in *December*, THE CHRISTMAS STAR. (See page 7.)

In *January*, STARS OF A WINTER'S NIGHT. There is no beauty more entrancing than that of the winter constellations. At this time of the year the sparkling giant Orion and his neighbors, Taurus, the Bull, and Canis Major, the Great Dog, illuminate the winter's night. The knowledge of the stars and the constellations is as rewarding as a close acquaintance with birds and flowers, making one ever more at home in the universe. During January the Hayden Planetarium presents the winter constellations in all their beauty. At this time, also, easy guide lines will be shown for the benefit of those who wish to learn the more conspicuous of the constellation figures.

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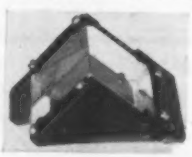

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GLEANINGS FOR A.T.M.s

Original Statement of the Foucault Test

FROM **Monthly Notices** (1858-59), **Proceedings** of the Royal Astronomical Society, R. S. Luce, of the Optical Division of the Amateur Astronomers Association in New York City, has supplied a photostat of what is apparently the first published description of the Foucault test. It is entitled, " 'Description of Various Processes made use of for Finding out the Configurations of Optical Surfaces,' by M. Leon Foucault (Communicated by Mr. De La Rue.)," and is reproduced in its entirety below:

"One of the principal advantages of the reflecting telescope consists in having, instead of an object-glass, a mirror which acts by means of a single surface; which surface being concave lends itself with remarkable facility to the application of the processes of examination which permit the appreciation of its figure even to the least details.

"I conjointly make use of three different processes. The first consists in placing very near to the centre of curvature a very small object, such as the point of a pin, in order to obtain an image of the same size as, and very near to the object itself; this image can then be observed by means of a microscope and compared directly with the object. We are thus enabled to judge with certainty by means of the amount of definition, of the effect which the mirror mounted as a telescope will give.

"If the image is imperfect, it is better then, with the view of ascertaining the faults of figure, to take a luminous point and observe the appearance of the pencil of light within and without the focus. It will be seen to decompose itself in partial images, the discussion of which gives at once some information respecting the configuration of the surface of the mirror.

"But the two processes I am about to point out are still preferable and give this information with greater precision.

"An object having parallel sides, such as the edge of a thin piece of steel, having one millimetre (0.03937 in.) in thickness is placed in the neighbourhood of the centre of curvature, and in order that the object may project itself in outline it is enlightened from the side opposite to the mirror, and the image which is formed by it, being on a luminous ground, becomes very apparent, and presents in its aspect some peculiarities which depend upon the figure of the mirror. This image being observed with the naked eye at the distance of distinct vision is seen in each of its parts, but, by means of rays passing through the pupil after having been reflected from a very small part of the surface of the mirror, so that in these circumstances the mirror only acts but partially, that is, by more or less restricted portions of its surface, which contribute severally to the formation of different parts of the image. Thus, if the curvature be not uniform, the different parts of the image will not form themselves in the same plane, and the angles subtended at the eye by the different parts will not be proportional to the corresponding part of the object; in short, the image will be deformed, contractions and dilatations will be seen, showing a decrease or an increase of the radius of curvature of the corresponding element of the mirror. The method becomes more correct and more conclusive, if instead of allowing the edge to have an indeterminate position in space, we fix on the eye-piece of a small telescope, magnifying but little, and provided with a narrow diaphragm comparable with the pupil.

"It is very rare that an image observed in such way will show itself free from any distortion, and such as a perfectly spherical mirror would give it, the edges instead of remaining rectilinear are bent most frequently in the shape of an hyperbola, and turn their concavity towards the interior of the field of the telescope; in presenting themselves under that shape they indicate that in every meridional section of the mirror the curvature goes on gradually diminishing from the centre towards the edge, which tends to correct to a certain degree the spherical aberration.

"Lastly, it remains now to describe a process which allows of the examination of concave surfaces, so as to recognize directly, by an effect of relievo, the elevated and depressed parts which affect the figure.

"A thin piece of metal, pierced with a small hole having 1/12th of a millimetre (0.00328 in., or about 1/305th of an inch) and enlightened by an artificial

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light, is placed within the centre of curvature, through that little hole the diverging pencil of rays falls on the surface which is being examined and comes back converging to form an image which is situated a little beyond the centre.

"By placing the eye in the cone of rays which diverge anew, and in bringing it towards the image, we at last receive the whole of the pencil of rays which passes freely through the pupil, and at the same time the surface of the mirror will be seen entirely illuminated. Now, if an opaque and rectilinear edge is brought near the image of the hole and be made to infringe on it by degrees, the mirror will also lose by degrees its brilliancy, and when all the light is about disappearing, the whole of the irregularities of the surface of the mirror will be plainly seen.

"In fact, supposing the surface to be correctly spherical, the image is perfectly well defined, and when allowed to emerge a little from the opaque screen which is brought forward to intercept it, the rays which are not stopped off come from the whole surface of the mirror which presents to the last a uniform brilliancy; if, on the contrary, this surface shows here and there some parts which are situated above or below the spherical level, the elements which do not present themselves under the proper incidence, these cause certain rays to deviate instead of converging with their fellow-rays (**congeneres**) towards the different parts of the image and to be dispersed in all directions.

"It results from this that every point of the image, and in particular each of those which emerge from the opaque screen, receives rays which do not belong to it, and does not receive those which do belong to it.

"The missing rays will leave in their corresponding places on the surface of the mirror a deficiency of light, the accumulated rays will produce an increase of intensity in others, and from the contrast of these different degrees of brilliancy and on account of an effect **clair-obscur**, an enormously exaggerated manifestation of the inequalities which really exist on the surface submitted to this sort of test will result.

"As the observation can only be made by means of a single eye, it happens that under a moral influence independent of the will of the observer, the valleys and hills seem to overlay each other; but with a little attention, what is a mere illusion will soon be distinguished from reality. In considering that the true rising parts are necessarily contained between two opposite declivities, one of which being turned towards the screen which hides the image appears dark, whilst the other presents an increase of brilliancy. In other words, the true figure of the mirror is analogous to that which would correspond to the apparent relievo interpreted in that hypothesis, in which an oblique light would come from that side opposite to the screen.

"This process offers, particularly, the advantage of being at the same time expeditious and direct; viz., a surface can be judged of in a few seconds, and, when it is defective, the faults of it are known immediately with great precision.

"Generally, all that has any influence on the direction of the rays, or anything which prevents them from converging simultaneously towards a point of common convergency, becomes visible and is found out. By means of this sort of observations, among several causes which affect the result, that one which exercises a predominant influence is easily distinguished from the rest. Thus the permanent irregularities of a surface will not be mistaken for the varying alteration due to the flexure of the mass of glass; and we can perceive the inequalities in the density of the ambient air which passes in whirling before the mirror, or which shows itself like stratified layers in the interior of the tube of the telescope. By taking the necessary precautions, all causes capable of producing an accidental disturbance are successively avoided, and the intrinsical faults or defects of the surface are the only ones which subsist.

"But, guided by the observation itself which causes them to be discovered, one succeeds, as I have demonstrated before, in correcting locally these defects; and lastly they can be reduced to such proportions as to exercise no sensible influence on the quality of the images.

"The mechanical processes by which the working of glass surfaces is usually

(Continued on page 21)

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OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern standard time.

A Fine Lunar Eclipse—December 18-19

SET ASIDE Tuesday evening, December 18th, right now, as one of nature's most satisfying displays, a total eclipse of the moon, will take place then, visible in its entirety to observers in North and South America. It occurs when the moon is well north of the equator and "riding high" in the sky, yet early enough in the evening for everyone to enjoy it without sacrificing hours of sleep.

The accompanying diagram gives a rough, graphical portrayal of the progress of the eclipse. As the moon is just 1½ days past perigee, the umbra is large and the penumbra relatively small. Consequently, first contact of the lunar disk with the umbra (I in the diagram) takes place before the moon is completely inside the penumbra. This occurs at 0:37.5, G.C.T. on December 19th, and is followed by second contact (II), when the moon becomes completely immersed in the umbra, at 1:40.5 G.C.T. The total eclipse begins then and lasts until 3:00.2 (III), or about one hour and 20 minutes. Central eclipse is at 2:20.3, M in the diagram. Fourth contact (IV) is at 4:03.1.

The penumbral contacts are on December 18th at 23:38.4, and on the 19th at 5:02.3. This and the information above are from the **American Ephemeris and Nautical Almanac.**

Position angle of contact I is 67° to the east of north, and of contact II, 81° to the west of north, and the moon's axis is practically due north and south, that is, its position angle is 0°.

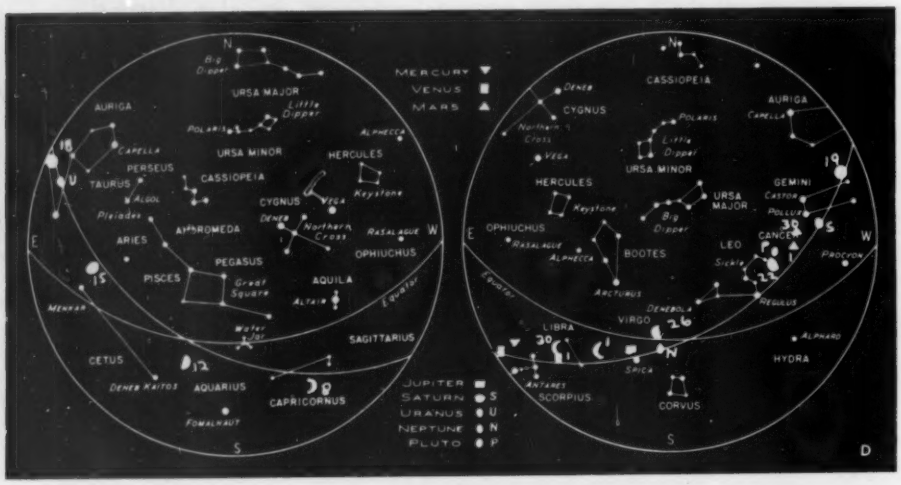
The following gives the standard times (9:41 p.m. on December 18th) of the contacts for observers in the United States. Since the time of the eclipse is independent of the observer's position, no further correction need be made:

Contact	I	II	III	IV
Eastern time	7:38	8:41	10:00	11:03
Central time	6:38	7:41	9:00	10:03
Mountain time	5:38	6:41	8:00	9:03
Pacific time	4:38	5:41	7:00	8:03

West Coast observers may have an opportunity to see the partially eclipsed moon rising while the sun is still visible in the western sky, a phenomenon observable only where the horizon is low and clear or where the observer can increase the dip of the horizon by attaining a high altitude himself. Particularly in northwestern California and along the coast of Oregon and Washington should this interesting event be possible of observation. The precise position is difficult to predict, but an observer at latitude about 40° north and west of longitude 120° would seem to have the best chance. Descriptions would be especially interesting, if the weather along the West Coast favors such observations.

Photographs of the partial phases may be made with telescopes without clock drives, but care should be taken to practice on the moon several days beforehand to determine the maximum exposure possible without obtaining a "move." The simplest shutter is a cardboard held over the skyward end of the tube, and an exposure of ½ second is usually ample for

THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 7:30 a.m. on the 7th of the month, and at 6:30 a.m. on the 23rd. At the left is the sky for 5:30 p.m. on the 7th and for 4:30 p.m. on the 23rd. The moon's position is given for certain dates by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

Mercury is the outstanding interest in December skies, for those willing to rise early to see it. For about a week from the 21st to the 28th of the month, the elusive planet rises before dawn commences, so it can be seen in a dark sky. On the 7th, Mercury passes inferior conjunction, and rapidly moves west of the sun, rising more than an hour ahead of it on the 14th. From then until the end of the month there should be little difficulty in observing the planet every morning, but do not confuse it with Antares, which is also of ruddy color, but much farther south. Greatest western elongation is on the 26th, 22° 12′, when Mercury will rise about 1¾ hours ahead of the sun.

Venus is on the far side of its orbit, near the full phase, but so near the sun as to have little observational interest. It is two degrees south of Mercury on the 12th.

Earth reaches heliocentric longitude 90° on December 22nd, at 0:04 a.m.; winter begins in the Northern Hemisphere, summer in the Southern.

Mars begins its retrograde motion on the 5th, and is of magnitude —0.7, nearly as bright as Canopus.

Jupiter is in Virgo, not far from Spica, but nearly as bright as Sirius.

Saturn is retrograding throughout the month; its magnitude is 0.0. It is a fine object for telescopic observation.

Uranus is at opposition to the sun on the 7th, when its magnitude is 5.9, visible to the naked eye. On the 1st, its position will be $4^h\ 57^m.9$, +22° 42′.1; on the 11th, $4^h\ 56^m.1$, +22° 39′.5; on the 21st, $4^h\ 54^m.3$, +22° 36′.8; on the 31st, $4^h\ 52^m.6$, +22° 34′.2.

Neptune is in Virgo; **Pluto** is in Cancer.

MIRA APPROACHING MAXIMUM

The well-known long-period variable star, Omicron Ceti, otherwise known as Mira, which has been under observation for more than three centuries, is again on its way to maximum, although with a slower start than usual. The predicted date of greatest brilliancy is December 10th, but what magnitude the star will reach is still uncertain.

It was noted a few years ago that when Mira was late in starting its increase in brightness, as in this instance, the approaching maximum was considerably fainter and flatter than normal, not sharp and steep as are the exceedingly bright maxima. Mira reaches maximum phase every 11 months, its brightest being recorded at anywhere between the 1st and the 5th magnitude, with an average maximum magnitude at 3.4.

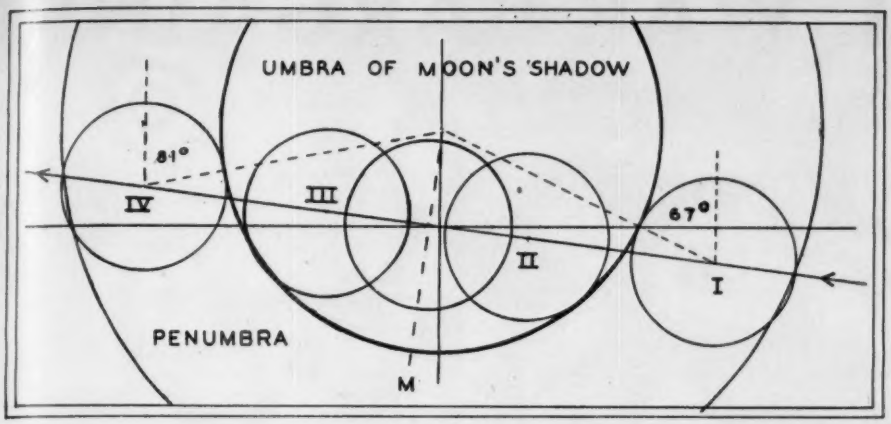
LEON CAMPBELL
Recorder, A.A.V.S.O.

GEMINID METEORS

Among the best meteoric displays of the year are the Geminids, which reach their maximum this year on the 12th of this month. However, they may be seen in good numbers many days before and after this date, radiating from the constellation of Gemini.

PHASES OF THE MOON

New moon .....December 4, 1:06 p.m.
First quarter ....December 12, 6:05 a.m.
Full moon .....December 18, 9:17 p.m.
Last quarter .....December 26, 3:00 a.m.



The path of the moon through the earth's shadow on the evening of December 18th.

the full moon. During totality, however, where very little light is present, and that mostly red, the exposure problem is serious, and a clock drive is almost essential.

For pictures showing whatever detail may be observable on the moon during totality, panchromatic or red-sensitive film should be used; Kodachrome also should give good results. While the partial phases may be photographed by projection through an eyepiece, it is recommended that the total phase be taken in the focal plane, to get the greatest possible concentration of light, as well as to improve image quality. It goes without saying that the longer the focal length of the telescope, the larger the image and the better the photographic results which are possible. Short focus, however, requires less exposure time, and, with a portable mounting, may result in a better picture. When making prints or enlargements of the partial phases, "dodging" should be tried to overcome the difference in density of the eclipsed and clear parts of the moon.

MINIMA OF ALGOL

Times of minima published here and in coming months are based on information kindly furnished by Dr. Joel Stebbins, from data derived at Washburn Observatory of the University of Wisconsin. The elements obtained from several minima, including one observed on October 6, 1942, are: Heliocentric minimum = JD 2430639.6741+2^d.8673178E. This represents various minima of the last 20 years with a maximum error of seven minutes. A difference of this magnitude may be introduced into any one observation by the light equation, the value of which depends on the position of the earth in its orbit.

Last month an error of an hour inadvertently occurred in our Algol prediction times. The minimum for November 26th, on the basis of the new data, is at JD 2431786.60122, or at 9:25 p.m. E.S.T. This prediction is 10 minutes later than that given in the **Observer's Handbook** of the Royal Astronomical Society of Canada. Further minima are for:

Nov. 29, 6:14 p.m.; Dec. 11, 5:30 a.m.; 14, 2:19 a.m.; 16, 11:08 p.m.; 19, 7:58 p.m.; 22, 4:47 p.m.

OCCULTATION PREDICTIONS FOR DECEMBER

11-12 **290 B Aquarii** 6.4, 23:11.8 —10-59.3, 7, +53° —25° Im: A 2:39.9 —0.1 +0.8 28°; C 2:36.1 —0.4 +0.7 34°; D 2:40.8 0.0 +1.6 13°; E 2:34.4 +0.1 +2.3 6°; F 2:13.5 —0.8 +1.6 28°.

12-13 **30 Piscium** 4.7, 23:59.1 —6-19.2, 8, +68° —15° Im: A 23:57.4 —0.7 +1.9 17°; B 00:03.2 —0.3 +2.2 7°; C 23:47.1 —0.8 +2.1 18°; D 23:58.1 +0.1 +3.0 358°; F 23:10.9 +0.1 +4.2 354°. Em: A 0:57.2 —2.1 —1.0 275°; C 0:50.2 —2.3 —0.6 272°; F 23:50.9 —4.0 —1.2 296°.

12-13 **33 Piscium** 4.7, 0:02.5 —6-00.9, 8, +73° —12° Im: A 1:50.3 —1.2 —0.2 66°; B 1:48.8 —1.0 +0.1 55°; C 1:44.5 —1.5 —0.1 69°; D 1:42.1 —1.2 +0.4 52°; E 1:25.1 —1.3 +1.1. 44°; F 1:02.3 —1.9 +1.3 55°; H 0:51.1 0.0 +3.7 357°. Em: A 2:58.5 —0.7 0.0 231°; C 2:54.5 —0.7 +0.4 225°; E 2:39.5 —1.5 —0.1 248°; F 2:24.4 —1.6 +1.0 231°; H 1:32.0 —3.5 —0.8 295°.

12-13 **24 B Ceti** 6.0, 0:07.5 —5-33.2, 8, +79° —8° Im: D 4:36.2 —0.8 —2.4 109°; E 4:33.1 —1.4 —2.8 114°; G 3:56.7 —0.9 +0.3 48°; H 3:44.7 —2.1 0.0 77°; I 3:46.8 —1.0 +0.8 40°.

15-16 **85 Ceti** 6.3, 2:39.5 +10-30.5, 11, +90° +8° Im: A 23:11.5 —1.3 +1.2 86°; B 23:14.1 —1.1 +1.3 79°; C 23:01.5 —1.2 +1.2 87°; D 23:05.3 —0.9 +1.5 75°; E 22:51.3 —0.5 +1.6 68°; F 22:34.0 —0.4 +1.2 80°.

24-25 **Nu Virginis** 4.2, 11:53.0 +6-50.3, 20, +90° +4° Im: A 10:05.5 —0.8 —2.7 163°; B 9:57.4 —1.0 —2.1 155°; C 10:17.6 .... 190°; D 9:57.6 —0.5 —3.2 172°; G 9:22.0 .... 185°. Em: A 11:11.3 —2.4 —0.3 266°; B 11:07.4 —2.1 —0.5 271°; C 10:54.3 —4.5 +2.5 240°; D 10:53.1 —2.9 +0.8 254°; G 9:46.5 .... 226°.

For selected occultations (visible at three or more stations in the U. S. and Canada under fairly favorable conditions), these predictions give: evening-morning date, star name, magnitude, right ascension in hours and minutes and declination in degrees and minutes, moon's age in days, limiting parallels of latitude, immersion or emersion; standard station designation, G.C.T., **a** and **b** quantities in minutes, position angle; the same data for each standard station westward.

Longitudes and latitudes of standard stations are:

A +72°.5, +42°.5	**B** +73°.6, +45°.6
C +77°.1, +38°.9	**D** +79°.4, +43°.7
E +91°.0, +40°.0	**F** +98°.0, +30°.0
G +114°.0, +50°.9	**H** +120°.0, +36°.0
I +123°.1 +49°.5	

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude respectively, enabling computation of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo — LoS**), and multiply **b** by the difference in latitude (**L — LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Greenwich civil time to your own standard time.

For additional occultations consult the **American Ephemeris and Nautical Almanac** and the British **Nautical Almanac**, from which these predictions are taken. Texas predictions were computed by E. W. Woolard and Paul Herget.

ORIGINAL STATEMENT OF THE FOUCAULT TEST

(Continued from page 19)

effected seem to lose of their efficacy as soon as they are applied to pieces of unusual dimensions; the results which they then furnish are but an approximation, a sort of trial which is far from being satisfactory; but where mechanism becomes powerless, the hand of man can do something more: assisted by the resources which optics put at his disposal, and guided by a system of observations the power of which increases with that of the instrument which is to be constructed, the human hand is then enabled to proceed with the work, and to carry it out to the greatest degree of precision.

"If it be required to verify by optical means any one of the ellipsoidal surfaces which lead from the sphere to the paraboloid, the same process can be applied identically, on condition, that the object which is used as a mark is placed at one of the foci, and the image examined at the other focus. The information which is got thereby, and the corrections which must be deduced therefrom, are based on the same appearances; only they have reference especially to the sort of surface given by the position of the foci, and the inequalities which are found out show deviations which are reckoned in the same way as for the spherical figure, viz., from the level of the correct surface which it is desired to obtain."

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OCULAR RETICLE, micrometer disc for eyepiece. Suitable for microscopes, telescopes, surveying, sighting, and other optical measuring instruments; also for counting, measuring, and locating as with cross-hair. Very accurately ruled. Rests on diaphragm, ruling can be seen in the field of view superimposed on image. Diameter .829". Baryta L.F. 1.58. Cross-hair and numbered net rulings. Our price only $1.00 each. Worth many times more. Quantity strictly limited.

No C.O.D.—Remit with order

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Scientific and Laboratory Apparatus

70 W. Broadway, N. Y. 7, N. Y.

UNUSUAL WAR BARGAINS in LENSES and PRISMS

TANK PRISMS

In order that the tank driver shall not get shot in the face, 2 of these Silvered Prisms are used to make a Periscope. We have secured a number of these that are very slightly chipped, making possible their sale at a very low price. They are 90-45-45 degree Prisms of huge size—5¾" long, 2⅛" wide, finely ground and polished. Used to build a Periscope . . . excellent also for experiments, class-room demonstrations. Some of our ingenious customers have used these prisms to make camera stereo attachment, range finder, etc. Prism easily converted into desk name plate by affixing gold etters. 100 gold letters supplied at only 10c. (Order Stock #3008-Y). Normally these Prisms would retail from $24 to $30 each.

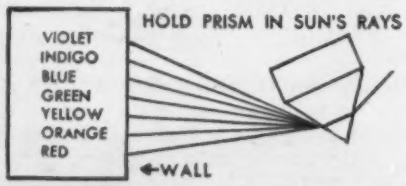
SILVERED TANK PRISM
Stock #3004-Y ..... $2.00 each Postpaid

PLAIN TANK PRISM
Stock #3005-Y ..... $2.00 each Postpaid

FOUR TANK PRISMS—Special—$7.00 Postpaid
The most **sensational** bargain we have ever been able to offer.

TO SEE THE COLORS OF THE SPECTRUM,

Hold a plain tank prism in sun's rays as shown in drawing. White incident light which passes through prism is thus broken up into a band of primary colors known as the spectrum—a beautiful sight! By looking through a tank prism at a certain angle, you can see a world of colors everywhere. Truly amazing!



All Items Finely Ground and Polished but Edges Slightly Chipped or Other Slight Imperfections Which We Guarantee Will Not Interfere with Their Use. Come Neatly Packed and Marked. EXCELLENT for XMAS GIFTS.

TO KEEP POSTED on all our new Optical Items, send 10c and your name and address to get on our regular "Flash" mailing list.

THICK FIRST SURFACE MIRROR—From Rangefinder—size 78 x 94 mms.—½" thick very flat optical glass. May have very slight scratch on chromium and aluminum coated surface. A $60.00 value.
Stock #533-Y ..... $2.00 Postpaid

8 MM. PROJECTOR CONDENSING LENSES . . . Consists of two Condensing Lenses with combined F.L. of ½ inch.
Stock #4027-Y ..... $1.00 Postpaid

RECTICLE SET—5 assorted, engraved recticles from U S. Gunsights.
Stock #2035-Y ..... $1.00 Postpaid

MAGNIFIER SET—5 magnifying Lenses—Powers from 1 to 10.
Stock #1026-Y ..... $2.00 Postpaid

LENS FOR KODACHROME EYE-VIEWER—Color corrected cemented Lens 38 mm. diam., 2 inch F.L.
Stock #6129-Y ..... $1.00 Postpaid

14-POWER COLOR CORRECTED MAGNIFIER SET—Consists of 2 perfect 18 mm. diam. Achromatic Lenses and section of metal tubing for mount.
Stock #1044-Y ..... $1.55 Postpaid

OPTICS FROM 4-POWER PANORAMIC TELESCOPE Excellent condition. Consists of Objective Prism, Dove Prism, Achromatic Objective Lens, Amici Roof Prism, Eye Lens Set (. . . a $60.00 value).
Stock #5016-Y ..... $6.00 Postpaid

MONOCULAR SET OF LENSES AND PRISMS . . . From Navy's 7 x 50 Binocular. All the optics you need to make a 7 Power Monocular. (Buy 2 sets to make a Binocular.) Complete Directions included.
Stock #5101-Y ..... $5.00 Postpaid

SPECTROSCOPE SETS . . . These sets contain all Lenses and Prisms you need to make a Spectroscope plus FREE 15-page Instruction Booklet.
Stock #1500-Y—Hand Type Spectroscope ..... $3.45 Postpaid
Stock #1501-Y—Laboratory Type Spectroscope. ..... $6.50 Postpaid

MICROSCOPE SETS

Consisting of 4 Cemented Achromatic Lenses for making a 40 Power Pocket Microscope or 140 Power regular size Microscope. These color corrected Lenses will give you excellent definition and may be used for micro-photography.
Stock #1037-Y ..... $3.00 Postpaid

Consisting of Prism, Mirror and Condensing Lens. These used together with Stock #1037-Y will make an excellent Microprojector enabling you to get screen magnification of 400 to 1000 Power according to screen distance.
Stock #1038-Y ..... $2.00 Postpaid

SPECIALS IN LENS SETS

Set #1-Y — "Our Advertising Special" — 15 lenses for $1.60 Postpaid, plus 10-page idea booklet. For copying, ULTRA CLOSE-UP SHOTS macrophotography, experimental optics, magnifying and for making a two power f/16 Telephoto Lens, "Dummy Camera," Kodachrome Viewer, DETACHABLE REFLEX VIEW-FINDER for 35 mm. cameras, stereoscopic viewer, ground glass and enlarging focusing aids, TELESCOPES, low power Microscopes and for many other uses.

Set #15-Y — "The Experimenter's Dream" — 62 Lenses, Prisms and Optical Items, and New 50-page Book, "Fun With Chipped Edge Lenses." $15.00 Postpaid. The variety of Lenses and Prisms in this set will enable you to conduct countless experiments, build a great variety of Optical Equipment. **A sensational buy.**

NEW 50-PAGE IDEA BOOK "FUN WITH CHIPPED EDGE LENSES"

Contains wide variety of projects and fully covers the fascinating uses of all Lenses in sets listed above . . only **$1.00 Postpaid.**

ALL THE LENSES YOU NEED TO MAKE YOUR OWN TELESCOPE!

ALL ARE ACHROMATIC LENSES

GALILEAN TYPE—Simplest to Make but has Narrow Field of View.

Stock #5018-Y—4 Power Telescope ..... $1.25 Postpaid
Stock #5004-Y—Small 2 Power Pocket Scope ..... $1.00 Postpaid

TERRESTRIAL TYPE—Have Much Wider Field of View than Galilean Type.
Stock #5007-Y—11 Power Telescope ..... $3.20 Postpaid
Stock #5008-Y—20 Power Telescope ..... $3.45 Postpaid
Stock #5009-Y—40 Power Telescope ..... $7.45 Postpaid

PRISM TELESCOPES—Use Prism instead of Lenses to Erect Image and are much shorter than Terrestrial Type. Have wide field of view.
Stock #5010-Y—6 Power Telescope ..... $3.00 Postpaid
Stock #5011-Y—11 Power Telescope ..... $3.25 Postpaid
Stock #5012-Y—20 Power Telescope ..... $7.25 Postpaid

MISCELLANEOUS ITEMS

Stock No.	Item	Price
2024-Y	10 Pieces Circular A-1 Plate Glass (Diam. 31 mm.—for making Filter)	.25
523-Y	Six Threaded Metal Reticle Cells	.25
26-Y	First Surface Aluminized Mirror, Diam. 1¼". Each	.25
624-Y	Neutral Ray Filter, size 4¾" x 2½"	.25
3022-Y	Round Wedge, 65 mm. Diam. Each	5.00
3021-Y	Amici Roof Prism (3rd grade). Each	.25
4009-Y	Heat Absorbing Glass 4" x 5". Each	.35
4010-Y	Heat Absorbing Glass 2" x 2". Each	.10
22-Y	Inclinometer—Aircraft type. Each	.25
704-Y	Lens Cleaning Tissue, one ream (480 sheets), size 7½" x 11"	1.50
1030-Y	2" Diam. Reducing Lens. Each	.25
1031-Y	Perfect 6 Power Magnifier. Diam. 28 mm.	.25

(Minimum Order on Above—$1.00)

RAW OPTICAL GLASS

An exceptional opportunity to secure a large variety of Optical Pieces both Crown and Flint glass (seconds) in varying stages of processing. Many prism blanks.

Stock #703-Y—8 lbs. (min. weight). ... $5.00 Postpaid

CLEANING BRUSH SET . . . For Lenses, Optical instruments, etc. Perfect quality—12 inch Flexible Plastic handle, hollow circular const. Range from stiff to very soft. 4 Brushes to set.
Stock #504-Y—(Reg. $6.00 value) ..... Price $1.00

PRISMS:

If you mount right angle Prism in front of Camera Lens and point camera straight ahead, you can take shot to left or right side without subject's knowledge. Technique successfully used by famous Press Photographers.

Stock No.	Type	Base Width	Base Length	Price
3040-Y	Right Angle	33 mms.	23 mms.	$1.00
3042-Y	Right Angle	41 mms.	40 mms.	1.00
3045-Y	Right Angle	70 mms.	168 mms.	8.00
3001-Y	Lens Surface	20 mms.	14 mms.	2.00
3006-Y	Porro-Abbe	9 mms.	9 mms.	.25
3009-Y	Porro	52 mms.	25 mms.	1.00
3010-Y	Porro	43 mms.	21 mms.	.50
3016-Y	Pentagon	45 mms.	22 mms.	.75
3029-Y	Dove	16 mms.	65 mms.	1.25
3036-Y	80 Degree Roof	60 mms.	36 mms.	4.00
6136-Y	Rhomboid	20 mms.	17 mms.	.50
3049-Y	Right Angle	69 mms.	167 mms.	10.00
3047-Y	Right Angle	53 mms.	103 mms.	4.00
3038-Y	Roof Prism	18 mms.	34 mms.	2.50

TANK PERISCOPE

Complete Set Mounted Components

Rugged, strong, originally constructed for U. S. Tank Corps. Consists of 2 fine Periscope Mirrors mounted in metal and plastic. Perfect condition. Only plywood body frame is required to finish this exceptional Periscope. First surface mirror is well protected by glass windows.

Set weighs 2¾ lbs. Overall length of mount 6⅛", width 2⅛". Would normally retail at $40 to $50.

Stock #700-Y ..... $3.00 Complete Set Postpaid
TWO SETS (4 UNITS) ..... SPECIAL $5.50 Postpaid

ORDER BY SET OR STOCK NO. • SATISFACTION GUARANTEED • IMMEDIATE DELIVERY

EDMUND SALVAGE COMPANY . P. O. AUDUBON, NEW JERSEY

DEEP-SKY WONDERS

AMONG marvels for observation in the December skies are the objects listed here, some of which are not shown on the chart above. The informal descriptions are for common telescopes. Norton designations are in parentheses.

Cassiopeia. NGC 663 (31^6), $1^h\ 39^m.2$, $+60°\ 44'$; cluster of 80 stars. M103, $1^h\ 26^m.6$, $+60°\ 11'$; cluster of 60 stars.

Eridanus. NGC 1291, $3^h\ 15^m.5$, $-41°\ 17'$; elliptical galaxy, near Acamar. NGC 1535 (26^4), $4^h\ 12^m$, $-12°53'$; small planetary, round, bluish, blurry.

Fornax. NGC 1097 (48^5), $2^h\ 44^m.3$, $-30°\ 29'$; spiral. Small, very dim. If you fail to find it, try the triple galaxy, M31, M32 and NGC 205, near Nu Andromedae.

Perseus. NGC 1528 (61^7), $4^h\ 7^m.6$, $+50°\ 59'$; cluster of 80 stars.

Camelopardalis. NGC 2403 (44^5), $7^h\ 32^m$, $+65°\ 43'$; spiral.

L. S. COPELAND

STARS FOR DECEMBER

from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., standard time, on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.